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NOTES AND COMMENTS.

The Passing of the British Foundry?

In a recently published work by an American engineer it is stated: "To anyone studying the matter (English iron output) in 1750, it would doubtless have been a very fair conclusion to assume that in a few more decades the British iron industry would be entirely extinct."

An editorial note which appeared in the first issue of the FOUNDRY TRADE JOURNAL in 1902 dealt with the same theme, quoting a telegram from Vienna stating: "Mr. Schwab, the preseident of the Steel Trust, prophesies, according to the "Neue Freie Presse," the collapse of the British iron industry. American competition would scarcely hit Continental production, but ruin the English. While American steel trade had trebled its production within the last decade, Britain's was at a standstill or decreasing."

At the moment, pessimists are constantly being met who propound the same theory.

If a complete survey is taken of the situation it will be seen that we have in this country all the potentialities necessary for the formation of a foundry industry well able to compete in the markets of the world. If liquid assets are at present restricted the basic ones are abundant. These may be summarised as efficient plant, good material, skilled workmen, technical men, fair transport and commercial integrity. The only factors needed are confidence, especially between master and man, a broader vision as to the adoption of new methods, whether British or foreign, and co-operation in research for the general good of the industry.

The remarks of speakers at the annual dinners of the Branches of the Institution of British Foundrymen express clearly that confidence in the revival of industry certainly is prevalent.

We have much evidence to show that British foundrymen are taking more than ordinary interest in the latest developments, and conservatism is being rapidly replaced by progressive tendencies.

If the newly-formed British Cast-iron Research Association is adequately backed by foundrymen as a whole there should be nothing to fear on this last score.

The Foundrymen's Competition.

Several of our correspondents are of opinion that we should have fixed the total expenditure so as to place all the competitors on the same basis. One competitor goes so far as to suggest that we should have included a fourth rule to read: "Expenditure on land and building, fixed plant, loose tools, stock working capital, filling in these items as you consider best."

We did not stipulate whether the foundry was to be on the production of cast-iron, steel or non-ferrous, as each type would require an entirely different amount of capital to evolve comparative plants. Our desire is to place all competitors on the same basis, and we are of opinion that leaving the conditions as open as possible adequately meets the case.

One good point is brought out by this correspondent in a query regarding levels. Though one is not usually sufficiently fortunate to find level ground on which to construct a foundry, we might assume, for the purposes of the competition, that an unlimited amount of level ground is available.

Is Coal-Dust a Refractory?

This question was discussed at some length at the conclusion of an excellent lecture recently given before the Birmingham Branch of the Institution of British Foundrymen, an account of which appears on page 108. According to Dr. Stansby's definition, which was quoted by the lecturer, *coal-dust is not a refractory*—if oxidation can be considered as a disintegration—but the use of powdered coal-dust on a mould face brings about a chemical reaction, which arrests the otherwise breaking down of the refractoriness of the facing sand. In order to clearly understand the reactions involved, it should be remembered that

THE FOUNDRYMEN'S COMPETITION.

FIFTY GUINEAS IN PRIZES FOR BEST DESIGN AND EQUIPMENT OF A FOUNDRY.

To mark the change over of the FOUNDRY TRADE JOURNAL from a Monthly to a Weekly publication, the Proprietors have pleasure in announcing that they are offering two Prizes of Thirty and Twenty Guineas respectively for an article dealing with the subject of the design and equipment of a Foundry (ferrous or non-ferrous), with special reference to the latest labour-saving devices and machines, internal transport and handling tackle

Competitors, by submitting articles, signify that they adhere to the following rules:—

(1) Competitors must be in the employ of an established British foundry subscribing to the FOUNDRY TRADE JOURNAL, or himself a subscriber.

(2) Articles must be illustrated with dimensioned drawings and sketches.

(3) The copyright of all papers and designs accepted for publication will become the property of the Proprietors of the FOUNDRY TRADE JOURNAL.

All papers must reach this office by Thursday, March 3rd, 1921. The decision of the Editor will in all cases be final.

silica (the base of all sands) combines with iron oxide (burnt iron) to form a fusible slag. Obviously, should a fusible slag be formed between the surface of the casting and the face of the mould, they will stick together in such a manner as to necessitate much fettling. If steps are taken to prevent the formation of oxide on the surface of the liquid or pasty iron, no adhesion to the sand will take place. The question therefore resolves itself into one of "selective oxidation," or, in other words, a material has to be found which will more readily unite with the oxygen, coming from no matter what source, and produce some substance which will not form a fusible slag with the sand. Coal gas meets the specification in every respect, providing means are provided for the adequate escape of the products of its combustion. Coal dust is merely a means to an end, and should be chosen solely on the volatile matter content. It would be just as reasonable to refer to a neutral or reducing atmosphere in contact with a graphite wall of a furnace as a refractory, as under such conditions the wall will last indefinitely, whereas, should an oxidising atmosphere play upon the wall at high temperature, it would result in its rapid destruction. We are of opinion, that even with a high percentage of ash, say, 15 per cent., such ash would be without effect. Apart from the considerations outlined above, it would be interesting to definitely ascertain whether temperature and reducing conditions are or could be sufficiently well established to reduce the iron oxide in the bond of the sand. At 750 deg. Cent. carbon reduces iron oxide (ferrous oxide) to metallic iron. A systematic research carried out on this question should be extremely useful in moulding practice.

Centrifugally Cast-iron Pipe.*

By A. F. MACALLUM.

While cast-iron pipe has been in use in France for over 250 years, its use in America did not commence until about 1817, when it was laid in Philadelphia as an experiment, which was so successful that it has been extensively used for water mains—and more recently for gas mains—since that date. It is a factor of great magnitude, not only in the development of modern water-supply projects, but in the broadening of many industries.

Attempts have been made to introduce varieties, but the bell joint has been for over a century, and is yet, the standard joint, and because of its long use may be regarded as having proved its inherent merit of design. Flanged pipe, although made for the first installations, was found too rigid for underground lines, besides being more expensive, and is now used only for special purposes.

Vertical Casting.

Cast-iron pipe was formerly cast on its side, but because of its tendency to be "out of round," or of uneven thickness, making a pipe easily broken and unreliable, this method of casting was abandoned and the pipe was cast vertically in moulds. This vertical casting gave very satisfactory results, although the pipe was still subject to blowholes, thin sides, cold shot, etc.

The present specifications for cast-iron pipe are based on iron having a tensile strength of 8.9 tons. When higher standards are given under the present foundry practice and mixtures, the pipe is apt to be brittle. On account, however, of new methods being adopted in manufacturing cast-iron pipe, consideration is being given to the revision of the specifications to meet these new conditions. This new pipe, developed by de Lavaud, a French engineer, is now being manufactured and introduced in this country after exhaustive comparative tests with the ordinary standard cast-iron pipe.

Centrifugal Casting.

The author has studied with great interest the manufacture of this new type of cast-iron pipe, which involves the application of the principle of centrifugal force to molten metal when poured into a permanent mould. A regulated quantity of molten iron is introduced into a revolving water-cooled, cylindrical mould, where, by the centrifugal force exerted, the molten metal is spread uniformly upon the inner surface of the mould. Within a few seconds the pipe is withdrawn from the mould at a red heat. The pipe is brittle after leaving the mould on account of the outer surface being chilled, but after passing through an annealing furnace it becomes tough and much stronger than ordinary cast-iron pipe, as plainly shown by recent tests made by Prof. Gillespie, of Toronto University. The pipe made under these conditions has a decided contrast in structure to pipe cast in sand moulds, and has not the segregation of impurities often found in sand-cast pipe. As a consequence, the pipe is a homogeneous, dense, fine-grained iron throughout, having no water or gas bubbles, and because of this density and strength it can be made much thinner.

* Paper read recently before the Montreal branch of the Engineering Institute of Canada.

Tests at Toronto University.

In the tests made by Prof. Gillespie a 6-in. pipe made by this machine was compared with a 6-in. ordinary sand-moulded pipe out of the same iron, with the following results:—

	Centrifugally cast pipe.	Sand-cast pipe.
Thickness, in.	0.28	0.51
Tensile strength, tons per sq. in.	16.5	7.1
Modulus of elasticity	14,500,000	8,860,000
Modulus of rupture	63,800	33,900
Quality factor	20.2	9.8

From these tests it will be seen that centrifugal pipe has very high tensile, cross-bending and resistance-to-shock values. It is apparent, therefore, that this type of pipe can be successfully made much thinner than the sand-moulded pipe. For example, a 12-ft. length of 6-in. pipe weighs 280 lb., as compared with 430 lb. for a sand-cast pipe of the same diameter.

In soils such as found in Ontario, cast-iron pipe suffers very little corrosion. The author has removed a section of old English cast-iron pipe laid in 1859 in Hamilton that showed no corrosion whatever, after being in the ground over fifty years. Even the weight marks were clearly legible. This old English pipe was made much thinner than called for by present-day specifications, and, being on a rising main, is still in service under more severe conditions from pressure than when laid.

The tests on de Lavaud centrifugally-cast-iron pipe show it, to all intents and purposes, impervious to corrosion, porbably due to the fact that the metal being cast under pressure is of such close grain as to resist the attack of corrosive matter. These centrifugally-cast pipe have a smooth exterior and interior surface, and, besides reducing hydraulic frictional losses, take a uniform surface coating. While the pipes are cast with standard bell ends they machine easily, and, because of the method of manufacture, the wall thickness is exactly uniform throughout and quite suitable for a threaded or straight-wall joint if desired.

This development in the manufacture of cast-iron pipe indicates what might be called a revolutionary advance over previous methods, and is certain to have a decided effect upon the production and consumption of cast-iron pipe.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

GENERAL COREMAKING.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—*Re* "Old Bill's letter in the FOUNDRY TRADE JOURNAL of the 20th inst. Would it be too much to ask "Old Bill" to give full particulars of the mixtures used by him for the sausage machine, and also for making cores, using sea-sand and a patent binder? The information given would be welcomed by all your readers, and especially by

Yours, etc.,

"YOUNG BILL."

A Melting Phenomenon.

In a recent issue of "The Foundry," Mr. G. P. Blackiston states that steel melts from the inside. In melting of steel in a crucible one of the pots broke during the melting process and was immediately removed from the furnace and set to one side. When the pieces were taken from the crucible they were found to be hollow.

Mr. Blackiston explains the phenomenon by stating that pure iron has a higher melting point than steel, and the more carbon there is in the steel, the lower its melting temperature. The outer layer of these bars of tool steel received the heat first, but this heat was, no doubt, immediately transferred to the inner portion. As the heat continued to be added, it is believed the carbon was burned out of the outer layer, forming it into a low-carbon steel approximating iron itself. The inner layer still retained its carbon.

CALCIUM SILICIDE.—According to the "Fonderie Moderne," the use of silicide of calcium is to be preferred as a dioxidiser to aluminium on the grounds that owing to the lower melting point of the former it rises more readily to the surface of the metal to combine with the slag.

Cast-Iron *v.* Semi-Steel.

At a meeting of the Manchester Association of Engineers last Saturday Mr. Ernest Wheeler read a Paper on "Cast Iron *versus* Semi-Steel." In the constant search for stronger and better materials of construction, so-called semi-steel has naturally received considerable attention from engineers and others desirous of obtaining, as a substitute for cast iron, a metal which shall have physical properties more nearly approaching to those of steel. The claims for semi-steel by its supporters are (1) that it is stronger than cast iron; (2) that it is more homogeneous and consequently less porous, and finally that it produces better wearing surfaces, *i.e.*, it offers greater resistance to wear than does cast iron—this applying presumably to cases such as internal-combustion engine cylinders. The tensile strength is stated to be from 13 to 20 tons per sq. in. and the transverse strength from 27 cwts. to 40 cwts. on a 1 in. square bar on 12-in. centres.

The graphitic carbon is stated to exist in a more finely divided form than in cast iron, and this is given as the explanation of the improved qualities of the material.

On the other hand, it is now generally recognised that the name semi-steel is a misnomer and that the product in reality is simply a variety of cast iron obtained by a method which is somewhat different from that prevailing in ordinary foundry practice.

The author has found it quite possible, without the aid of steel, to prepare and obtain mixtures of cast iron having a tensile strength of over 18 tons per sq. in., and this is confirmed by other workers in the same field.

Methods of Manufacture.—Genuine semi-steel, crucible melted in a neutral atmosphere, has a composition ranging between that of the cast iron and steel used in its making. The effect of the steel additions to ordinary soft cast-iron is then to reduce the percentages of carbon, silicon and phosphorus, thus producing a purer, stronger and closer iron. Under such conditions as the above, any desired composition can be secured by judicious mixing and the process is one which readily lends itself to scientific control. Turner's well-known researches on the influence of silicon on cast iron were carried out by adding carbon to wrought iron and then adding varying amounts of a 10 per cent. silicon pig-iron, the whole of the experiments being done in covered crucibles. For special reasons given by Turner the carbon in the resulting metal was kept round 2.0 per cent. The phosphorus did not exceed 0.34 per cent. Considering these points, the experiments could perhaps be more correctly described as having been made on material of the nature of semi-steel rather than on ordinary cast-iron which contains round 3.5 per cent. of carbon and 1.0 per cent. phosphorus. The highest tensile strength recorded in Turner's experiments was 15.7 tons per sq. in., this bar containing 1.95 per cent. silicon and 2.18 per cent. carbon.

The ordinary method of making so-called semi-steel is by the addition of steel scrap to the charge in the cupola, and this is the most practical and economical method. In this case the results cannot be controlled with the same ease or certainty as in the first method. The economical aspect is so much more favourable, however, that the cupola method becomes worthy of very careful investigation and consideration. Various percentages of steel may be added to mixtures of cast iron, depending on the nature of the requirements and the metals used. Usually these percentages range from 10 per cent. to 25 per cent., and in certain other cases up to as high as 50 per cent. A favourable proportion for ordinary work appears to be round 15 per cent.

A large number of important British and American motor-car engine cylinders are now made of semi-steel, and for this purpose a 25 per cent. to 30 per cent. steel mixture is generally recommended.

Composition and Properties.—The analyses of an ordinary cast-iron, of common mild-steel scrap and of a mixture containing equal proportions of each, *i.e.*, a 50 per cent. semi-steel, crucible-melted, are represented by the figures given in Table I.

TABLE I.—*Analyses of Soft Cast-Iron, Mild Steel and Semi-Steel.*

	Soft cast-iron. (1).	Mild steel. (2).	50% Semi-steel mix. of equal parts. (1 and 2).
Silicon	2.60	0.20	1.40
Sulphur	0.04	0.06	0.05
Phosphorus ..	1.00	0.10	0.55
Manganese	0.50	0.50	0.50
T. carbon	3.60	0.20	1.90
Iron	92.26	98.94	95.60
	100.00	100.00	100.00

From a consideration of these figures and of the known tensile strengths of the cast iron and mild steel used, which are approximately 10 tons and 30 tons per sq. in. respectively, it does not seem reasonable to expect a tensile strength of over 20 tons per sq. in. from an ordinary semi-steel, and this is probably the maximum strength obtainable.

C. A. Keller produces a special form of semi-steel in the electric furnace by the simultaneous melting and carburisation of steel-scrap turnings, having a composition of: Carbon, 2.9 per cent.; silicon, 1.75 per cent.; manganese, 0.50 per cent.; phosphorus, 0.05 per cent.; sulphur, traces.

The tensile strength is 31.7 tons per sq. in. The impact resistance is 60 blows, the method, being dependent on the use of an electric furnace, is expensive under ordinary conditions, but it gives a much stronger product than ordinary foundry mixtures melted in cupolas.

So far as the tensile strength of ordinary semi-steel is concerned it would appear that within limits this is in direct proportion to the strength of the iron and steel used. The results obtained by the author and given in Table II. are indicative of this.

TABLE II.—*Tensile Tests of Semi-steel Mixtures.*

Materials used in the tests below:—
Soft cast iron of 10 tons sq. in. tensile strength.
Mild steel of 30 tons sq. in. tensile strength.

Mixture.		Product.	Tensile strength. Tons sq. in.
Cast iron.	Mild steel.	Semi-steel.	
90%	10%	10%	12
85%	15%	15%	13
80%	20%	20%	14
75%	25%	25%	15
70%	30%	30%	16

It will be seen from the figure given in this table that each 5 per cent. of steel added to the mixture has increased the tensile strength by one ton per sq. in. To obtain results approaching 20 tons per sq. in. is more difficult, and although strengths of 17 to 18 tons per sq. in. can be regularly maintained, under proper conditions, it is necessary in such cases that very careful control be exercised if the results are to be constant over a long period.

In routine tests of metal for gas and oil-engine liners of various sizes the author obtained an average tensile figure of 16 tons per sq. in. from the usual liner metal containing no admixture of steel, and from hundreds of similar liners cast with mixtures containing varying proportions of steel similar tests averaged just under 14 tons per sq. in., the highest figure reaching 17.3 tons in the first set of tests, and 15.8 tons in the second set. These figures are intended to demonstrate that ordinary cast-iron mixtures can be and are obtained of more than equal strength. The prospect of being able to repeat such tests regularly is remote unless the work is carried out under skilled or scientific supervision, and particularly is this so when strengths over 18 tons per sq. in. are desired.

It will probably be noticed that much attention has been devoted to the tensile strength. In conjunction with a suitable impact test the tensile test gives valuable information to the engineer, and it has the great advantage of being very precise and reliable. According to the well-known tests of Ludwig Lœwe there is a distinct relationship between the tensile strength and the wearing properties of cast iron. This investigator found that a strength approaching 14 tons per sq. in. gave a metal on which the wear by rubbing was almost nil, while an iron having a strength of just over '0 tons per sq. in. lost 10 per cent. of its weight, and another iron of just over seven tons per sq. in. lost 70 per cent. by weight under an exactly similar rubbing test. These results are taken to indicate that for wearing purposes a tensile strength of 14 tons per sq. in. or over is ideal. Turner also states that in all specimens of exceptionally high-tensile strength which he had examined the metal was a soft, good working quality specially suited for engineers' purposes, and in this connection Smith and Primrose quote instances of liners made of soft iron having given excellent results, and indicate that hardness by itself is not so important as the microstructure which should show the graphite in a small and evenly divided form.

An impact value of 27 blows is equal to that number of blows from an average height of 41 c.m., and a figure of 60 blows represents that number of blows from an average height of 57.5 c.m. The French Commission specified 18 blows, which works out at an average height of 36.5 c.m. per blow.

In discussing tensile and impact tests, it is necessary to remember that in a really good iron both these figures must be satisfactory. Sulzer Bros. having made several experiments, decided that a round bar was the

most suitable form of bar for making tensile tests, and they also found that with rapid cooling the strength of the iron became greater while its resistance to shock decreased. It is generally admitted that a round bar is the best for tensile testing, and here the author would lay special emphasis on the importance of this bar being produced by a proper method, such as one of the following: (1) By moulding from a suitably chosen pattern and pouring separately. (2) By moulding from a suitably chosen pattern and pouring attached to the casting. (3) By cutting an actual representative piece out of the casting itself. In each case the bar is to be finally turned accurately to size.

The size of the bar should vary with the size of the casting, and it is very necessary that it should be such as to represent, as nearly as possible, the strength of the metal in the casting itself as determined by method (3) in cases wherever this method is possible. The physical tests and properties of the three materials chosen for comparison are set out in Table III.

TABLE III.—*Physical Tests of Semi-steel and Ordinary Cylinder Iron.*

Physical tests.	A. 25% Semi-steel (crucible melted).	B. 25% Semi-steel (cupola melted).	C. Ordinary cylinder-liner iron (cupola melted).
Transverse test on 1 in. × 1 in. × 12 in. centres—cwts. (machined bars) ..	33½	31	28
Tensile test. Tons per sq. in.	15.2	15.5	15.4
Impact test. No. of blows	20	22	20
Relative density at 60 deg. Fah. ..	7.292	7.173	7.326
Calculated weight of 1 cub. ft. in lbs. ..	454	447	456
Brinell hardness No.	228	228	228
Shore's hardness No.	37	35	42

There is a marked difference in the transverse tests and here the author would say that in his opinion this test can only be looked upon as a very rough one and in no way comparable with a carefully conducted tensile test.

Pilkington, who had many opportunities for judging, went so far as to state that he had given up transverse bars as being of no scientific or any other value, and had adopted a machined tensile bar which he considered to be the only valuable test.

Although the transverse may not be considered an accurate test, it does give a rough idea of the strength of the metal, and is quite useful when properly understood and interpreted.

The impact test has been mentioned previously, and in this respect all the samples are good and practically identical.

In the case of the densities the figures are normal and A and C compare closely with the density of hard cast iron, while sample B compares closely with medium cast iron.

Regarding the hardness tests, the Brinell readings are the same. The scleroscope tests seem more delicate and show slight differences in the three samples.

The chemical analyses are embodied in Table IV.

TABLE IV.—*Chemical Analyses of Semi-steel and Ordinary Cylinder Iron.*

Chemical analysis.	A. 25% Semi-steel (crucible melted).	B. 25% Semi-steel (cupola melted).	C. Ordinary cylinder-liner iron (cupola melted).
Silicon	1.27	1.41	1.00
Sulphur	0.07	0.10	0.12
Phosphorus	0.75	1.04	1.30
Manganese	0.45	0.37	0.30
Graphite carbon ..	2.30	2.45	2.30
Combined carbon ..	0.75	0.63	0.76
Total carbon	3.05	3.08	3.06

The results show the total carbon to be the same in each case. The combined carbon is slightly lower in sample B than in A and C, which are alike in this respect.

Silicon varies from 1.0 per cent. to 1.41 per cent., percentages which are generally considered to indicate fairly good strong irons, such as these undoubtedly are.

Sample A contains the lowest phosphorus, viz., 0.75 per cent., and this was purposely arranged so as to give this metal every chance of showing high physical tests.

Sample B contains 1.04 per cent. phosphorus, and this may be considered a normal quantity, while sample C has 1.30 per cent. phosphorus, which the author's experience has not shown to cause any trouble when associated with a strong physical structure.

In speaking of phosphorus it is admitted that there is, or has been, quite a general impression that high phosphorus, say over 1.0 per cent., must necessarily cause a cast iron containing it to be weak and brittle. Years ago, W. J. Keep published a lengthy research on the influence of phosphorus in foundry iron, and he reported that "while phosphorus of itself, in whatever quantity present, weakens cast iron, yet in quantities less than 1.5 per cent. its influence in this direction is not sufficiently great to overbalance other beneficial effects which are exerted before the percentage reachs 1.0 per cent." The author considers this verdict holds good to-day, and the growing tolerance with regard to phosphorus, which is now acknowledged by many writers to be beneficial rather than otherwise when proper precautions are taken to keep the physical structure close and sound, confirms the general statement. An excellent example of this tolerance in modern foundry practice is in the casting of certain motor-car cylinders, large numbers of which are at the present time made from iron containing 1.5 per cent. phosphorus, and as these are quite successful in use this metal certainly cannot be weak and brittle or it would not be satisfactory for such severe work. The author has obtained a tensile strength of over 18 tons per sq. in. from a cast iron containing over 1.3 per cent. of phosphorus.

TABLE V.—*Foundry Tests on Semi-steel and Ordinary Cylinder Iron.*

Foundry tests.	A. 25% Semi-steel (crucible melted).	B. 25% Semi-steel (cupola melted).	C. Ordinary cylinder-liner iron (cupola melted).
(1) Shrinkage test on ½ in. sq. bars 12 in. long	0.190 in.	0.170 in.	0.180 in.
(2) Chill block test ..	¾ in. white	½ in. white	¼ in. white
(3) Casting temperature	Very hot (Approx. 1400° C.)	Hot (Approx. 1300° C.)	Hot (Approx. 1300° C.)
(4) Appearance of molten metal as cast	Rather sluggish	Fluid	Fluid

A few foundry tests are enumerated in Table V., and they are almost self-explanatory. The deep chill given by sample A is probably due to the high pouring temperature and the lower percentage of phosphorus. The fractured surfaces of the tensile bars were carefully polished and examined microscopically

So far as the tests which have been described are concerned, the semi-steels A and B do not show any real superiority over the ordinary iron C, and they demonstrate the now generally admitted fact that the term is a misnomer, and that the product is simply a cast iron. If anything, the ordinary iron is the densest of the three samples although the difference is small.

With regard to semi-steel many conflicting opinions are on record, and some of them emanate from the same authority, thus making it difficult for a student of the subject to reach a correct conclusion. For instance, Hurst states that although "cupola melted semi-steel must be considered a failure when considered from the standpoint of those people who urge the wonderful results of this product yet it is without doubt that semi-steels possess excellent wearing qualities." This he "attributes largely to the character of the free carbon which in a carefully prepared semi-steel is somewhat different from that in normal cast iron, it being much more firmly embedded in the matrix. This tends to prevent the loosening of the grains composing the surface of the cast iron under the influence of the wearing action, thus preventing that which is largely responsible for wearing in cast iron.

The question to be solved by this paper is whether semi-steel of similar analysis or of slightly purer composition has any real advantage over ordinary cylinder or liner iron. The results obtained in practice with the metal represented by sample B have been very consistent, and such as to lead to the conclusion that so called semi-steel of this nature is quite a useful and reliable product

In the semi-steel B the metal from the cupola has been more regular in quality than the ordinary liner iron. It has a better change of being so on account of the difference in the respective mixtures, and this is quite a good practical point.

The extravagant claims of the semi-steel enthusiast are not borne out: but it has been demonstrated that such mixtures have their advantages and their more common adoption should go some way towards solving the problem of obtaining suitable and consistent qualities of cast iron.

Electrical Resistance Furnaces.

The Leeds Electrical Construction Company, Limited, have developed and placed upon the market an interesting range of electrical resistance furnaces, which embraces furnaces for hardening and tempering steel wire and strip, general heat-treatment furnaces, furnaces for melting non-ferrous metals, rivet heaters, etc.

The furnaces, designated "Lecfur," are the outcome of several years' experimental work, and constitute a novel and at the same time important advance in the application of electricity to furnace work. The most striking and perhaps the most important departure is the furnace designed for the hardening and tempering process for steel wire and strip. Hitherto the only methods available for such work were by solid-fuel, gas, or oil furnaces, and with such furnaces there is the ever-present difficulty of maintaining accurate temperature control. The method most usually employed is to heat by gas and quench in oil, or other suitable bath, a system which ensures very useful results, though naturally the loss by radiation with gas heating is very excessive, and the thermal efficiency is therefore low. Further, any variation in the pressure or the quality of the gas supply affects the quality of the work; it is true that the pressure can be regulated within narrow limits with a suitable governor, but there is no system available to compensate for the variable calorific value of the gas.

Other things being equal, the electric furnace is ideal for the work referred to, as in such a furnace the temperature is under perfect control. The metal is heated in a non-oxidising atmosphere, which results in an entire absence of scaling or discoloration of the metal under treatment, and of course there are no products of combustion to be dealt with.

In addition to fully meeting the above requirements, it is claimed for the Lecfur furnace that, whilst its operation is within the scope of the unskilled labourer, the working charges are considerably lower than with solid-fuel, gas or oil furnaces. In the Lecfur system the wire or metal to be treated is made the conductor, being heated directly by the flow of current passing through the travelling material, the electric resistance of the metal and the current flowing through the same producing the desired temperature, the current being adjusted by suitable electrical control. This method of heating, of course, results in the best economy, as resistance heating never consumes current unless useful work is being done.

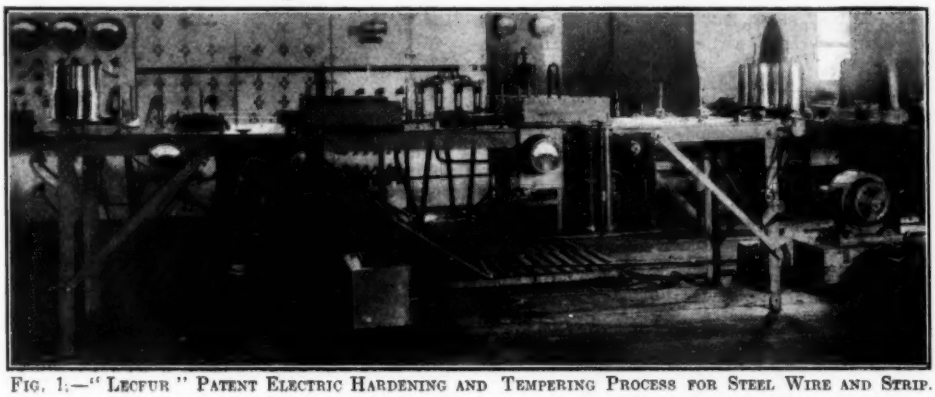

FIG. 1.—"LECFUR" PATENT ELECTRIC HARDENING AND TEMPERING PROCESS FOR STEEL WIRE AND STRIP.

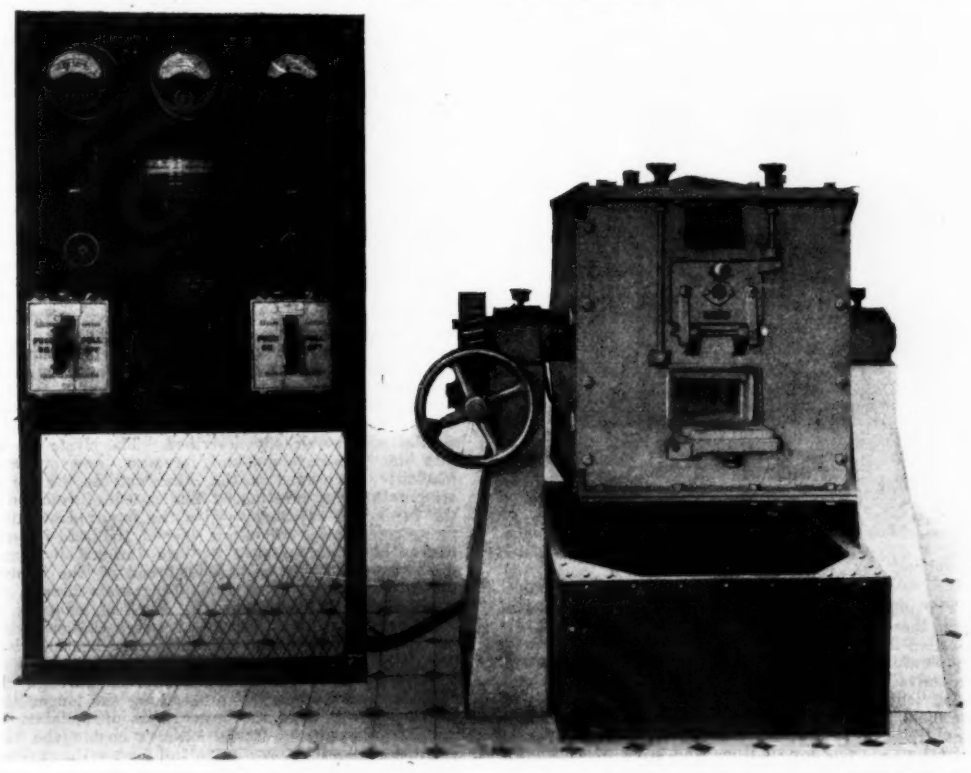

FIG. 2.—ELECTRIC RESISTANCE FURNACE (TILTING TYPE) FOR HEAT TREATMENT OF CARBON AND ALLOY STEELS.

The travelling metal, passing on through an oil trough, is hardened, and on leaving the quenching tank is electrically re-heated to the required temperature for tempering, as indicated by a special control indicator, and finally quenched in a second oil-filled trough. The oil in the troughs is maintained at the proper temperature by suitable coolers. From the

final bath the wire passes round a tension pulley and is wound on to revolving drums. The speed at which the wire or strip passes through the machine is regulated by adjustment of the gears of the winding drums. Embodied in the equipment is a patent magnetic detector for denoting the recalescence point prior to final quenching. This is a valuable asset, as it enables the operator to obtain with accuracy the correct temperature to which the steel should be heated prior to quenching. An indicator marked in gauges of wire and speed of travel per minute is fixed on the machine, so that all the operator has to do is to turn the control wheel until the pointer indicates the gauge of wire under heat treatment. An important feature of the process is that if the wire or strip is not uniformly drawn, this is shown by the indicator, thus eliminating the possibility of hardening and tempering material which is afterwards found not to be uniformly drawn.

The furnaces for the heat treatment of metals are made in several types, Fig. 2 showing the tilting type, which is particularly suitable for the heat-treatment of carbon and alloy steels. The furnace, it will be noted, is of the twin-chamber type, each chamber being under separate electrical control, so that the furnace can be used for hardening and tempering. The arrangement is such that when the contents of each chamber have reached the desired temperature, as shown by the pyrometer on the control panel, the furnace can be tilted to the required position for discharge. The doors of the furnace are then opened by spring-latch mechanism, and the contents of the chambers automatically discharged into the quenching tank, which is placed as shown between the supports of the furnace.

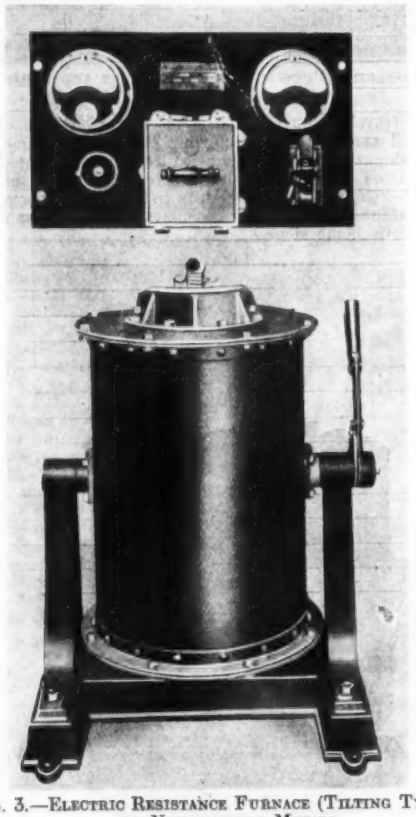

FIG. 3.—ELECTRIC RESISTANCE FURNACE (TILTING TYPE) FOR NON-FERROUS METALS.

The muffles are of a special refractory material of high thermal conductivity and low co-efficient of expansion, and are capable of working continuously with temperatures up to 1,600 deg. C. A special feature of the refractory is that it does not soften even at elevated temperatures, thus eliminating the possibility of the metal in the furnace sticking to the muffle, which is a frequent source of trouble with certain types of refractories. The top, bottom, and sides of the muffle are uniformly heated, the metal under treatment being mainly heated by radiation, thus ensuring that uniform heating which is essential if distortion is to be avoided when the metal is quenched. Replaceable mica windows are fitted in the furnace doors, which allow the contents of the furnace to be inspected without opening the doors. With the standard furnace a temperature regulation of 25 per cent. is provided, but other regulations can be given to meet special requirements.

There are, of course, many advantages to be derived from the melting of non-ferrous metals in the electric furnace. In such a furnace the metal is brought down in practically a non-oxidising atmosphere, reducing to a minimum losses due to oxidation and volatilisation. Further, the temperature is under perfect control, enabling the metal to be poured at any pre-determined

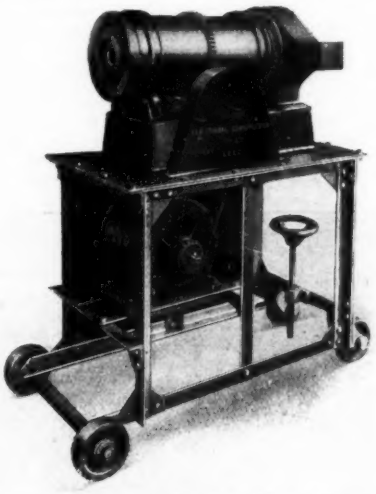

FIG. 4.—AUTOMATIC ELECTRIC RIVET HEATER.

temperature. It is widely recognised that for melting aluminium and certain other alloys, the question of temperature control is most important in order to obtain high-quality work. Absorption of gases by the molten metal can be avoided, as the atmosphere of the melting chamber is under control.

The furnace shown in Fig. 3 is designed to take a charge of 50 lbs. of brass. Of the vertical cylindrical type, it is supported on a cast-iron stand and baseplate with the tilting mechanism arranged so that the furnace is self-sustaining in any position. The heating element is a special high-temperature alloy wound in intimate contact with the melting chamber; there is an entire absence of joints and electrical connections, which are a frequent source of trouble in all high-temperature apparatus. The melting chamber is supported between circular refractory discs capable of standing high temperatures without distortion or cracking, provision being made for expansion and contraction. The space between the refractory discs and the outer shell of the furnace body is filled with special lagging powder of extremely good heat-insulating properties. Attached to the top plate of the furnace is a semi-circular casting lined with refractory material, which serves as the pouring spout. This spout being heated by conduction of the furnace charge, solidifying or cooling of the metal during pouring is obviated. The exterior of the furnace body is treated with aluminium in order to reduce the loss of heat by radiation and improve the thermal efficiency. The average time taken to melt a charge of brass is approximately 35 minutes, and the current consumption about 0.18 unit per lb. of metal poured.

The electric rivet heater is, as Fig. 4 shows, a self-contained and portable unit, being mounted with its driving motor upon a wheel base. The construction of the furnace chamber and the heating element is similar to that already described. The rivets are fed into the furnace shank-end foremost, and are automatically discharged at the other end at the correct temperature for riveting. The speed of rotation of the furnace is adjusted to give the required output of rivets per minute. Should a rivet be fed head-foremost instead of shank foremost into the furnace, it is automatically discharged at the feed end of the furnace. The time taken for a rivet to travel through the furnace is dependent upon the speed of rotation, the size of the rivet, and the ratio between the length and dia. of the rivet. As an example, when heating rivets of the same dia. but of unequal length, the heavier rivet takes a longer period to travel through the furnace, thus automatically obtaining the longer time required for heating the larger mass of metal to the same temperature. These features enable the rivet heater to operate at practically full load with maximum efficiency, irrespective of the size of the rivets being heated. A test taken on the machine illustrated gave 240 rivets ¾ in. dia. × 2 in. long, heated to riveting temperature for a current consumption of 5 B.O.T. units, inclusive of the current required for driving the motor.

The furnaces described above are manufactured under Imbery-Alexander patents by the Leeds Electrical Construction Company, Limited, of Charmouth Street, Leeds.

Buying Castings.

There are a great many engineering factories which use a large number and a great variety of castings, but which, not possessing a foundry, must depend wholly upon supplies obtained from outside. It is in this connection that trouble is sometimes experienced; a good deal of which is directly attributable to the method of buying; it is proposed, therefore, to deal with this aspect and endeavour to outline a form of procedure which, if followed, should eliminate a vast amount of trouble.

Where the business associations between the factory and the foundry are long standing it is safe to assume that the foundry has a fair understanding of the requirements of the factory, and can be relied on to give satisfaction. It may be that, during the war, the factory was practically tied to a certain foundry, and although perhaps, in the early stages, the foundry did not give entire satisfaction, it perforce had to be persevered with, the result being that "practice making perfect," the product and the delivery reached the standard desired.

After the buyer has placed his order with the foundry, and has received castings which have failed to give satisfaction, he jumps to the conclusion that the foundry is but a third-rate concern, and cannot produce the high grade material he desires. Consequently, his orders are placed elsewhere, and the foundry does not get another opportunity of making good.

There is no doubt that, for satisfaction to be obtained, the foundry must understand the essentials of the customer's business, and for this to be made possible the foundry must be persevered with. This is particularly the case where the castings required are of a somewhat intricate design, and it may be that several months will elapse before a casting, which gives entire satisfaction, is received. Where a factory possesses a foundry of its own, all the castings must be produced by that foundry, and if these castings do not give satisfaction, then the management is forced to take the necessary steps to effect an improvement. Although the outside foundry cannot be forced, it can be coaxed, and if it is given the opportunity it will usually rise to the occasion, for the recognition that it is being afforded the opportunity, coupled to the knowledge that repeat orders depend upon its success, is a very powerful incentive.

Assuming that satisfactory castings are being received from one foundry, but that this foundry cannot cope with the demand. To supplement supplies it is necessary to place an order with another foundry, but the castings received from this second foundry are decidedly inferior. What is to be done? Should the buyer at once turn his attentions elsewhere, or should he persevere with that foundry, in the hope of effecting an improvement?

His decision is governed by certain factors, which should not be disregarded. In the first place his supply of patterns may be limited, and, obviously, he does not take from the original foundry any patterns which can be kept in constant use. Suppose for one article he has five patterns, and the first foundry can handle three. The other two are sent to different foundries, it not being good policy to send the two to one foundry, until that foundry has proved its capabilities.

Calling these two foundries A and B. Foundry A is prepared to do the work and in course of time submits a sample casting, which is not approved. But before withdrawing the pattern it is well to consider whether the casting submitted, although rejected, may be regarded as promising. It must be remembered that it is a first attempt, and, although not up to standard, still is by no means hopeless. The defects are pointed out to the foundry, and the attitude of the foundry manager in this respect is of some importance. He may consider that he has turned out a pretty good casting, and challenge the rejection, or he may have discovered, after practical experience, that he cannot do what is required. In this latter case he unhesitatingly says so, even though expressing his willingness to try again, and in this case the buyer's course is obvious. He withdraws the pattern and tries elsewhere. In regard to the case where the rejection is challenged, the buyer must be governed by circumstances. The challenge may be quite genuine, and a joint inspection of the casting by the managers of the foundry and the factory may result in another sample being submitted, more in accordance with the requirements.

It may be, however, that the rejection of the casting is accepted by the foundry, and the wish expressed that it may be allowed to try again. Here there are distinct possibilities, which the buyer would do well not to ignore. It may be assumed that the foundry can see what errors have been made, and how they can be rectified, whilst confidence is expressed by the foundry that it can produce what is required. In such a case the opportunity should be given, and it may be that, although the next sample, when submitted, is still not up to standard, it is a distinct improvement upon its predecessor, and ultimate success is assured.

Another point which must not be ignored by the buyer is the importance of getting the best value possible from the patterns. He has, in accordance with the illustration, five patterns for one specific piece, three of which are happily placed, and producing (as far as can be ascertained) the maximum number of castings. The remaining two are subject to some speculation, as these, being placed with foundries on a more or less experimental basis, obviously cannot be utilised to the full extent.

The onus is upon the buyer to place his orders to the best advantage, and it is assumed that he is so doing when he sends one to foundry A and the other to foundry B. He has taken into consideration the fact that for probably some weeks these patterns will not contribute toward his supplies, but in this respect he is risking nothing, seeing that, even had the patterns been allowed to remain in the original foundry, they still would have been non-productive, on account of the inability of the foundry to handle them.

On the contrary, he is exploring a new avenue, with an eye to future possibilities of obtaining a new source of supply, but the test comes with the arrival of the sample casting. Taking the case of foundry B, it is assumed that the first sample is unsatisfactory, the same remark applying to the second and the third, although each succeeding one is an improvement upon its predecessor. After the arrival of the third casting the buyer begins to doubt his wisdom of allowing the pattern to remain, and at length he may decide to take it away and place it elsewhere.

Each case must be dealt with on its merits, for it is hard to determine, without inside knowledge of a specific case, whether or not the buyer is acting wisely in withdrawing the pattern. It is admitted that the samples continue to improve, even though the standard has not been attained, but it is a remarkably slow development, and is not helping to solve the problem of adequate supplies. Still, it is possible that within a week or so standard castings will continue to arrive, and in that case the retention of the pattern by foundry B is justified. On the other hand, many weeks may elapse and still the hope remains unfulfilled, and so the pattern remains non-productive, the buyer speculating on what might have been accomplished had the pattern been withdrawn and placed elsewhere at an earlier stage.

So after the third abortive sample has been received the buyer must consider whether he shall withdraw or go on. The pattern has already perhaps been tied up for four or five weeks, and he knows that should he place it elsewhere it will probably be non-productive for a further four or five weeks, with the possibility of the situation remaining unchanged, so far as production is concerned. The whole position bristles with difficulties, and no hasty action should be indulged in, but, on the other hand, the tying-up of a pattern for an unlimited period does not commend itself to the management, which naturally expects the facilities provided to be utilised.

The factory needs castings, and the buyer must get them. The shop foreman objects when he is short of work, and demands adequate supplies of material. He is not concerned with the difficulties of the buyer. He wants to know what is being done, and when he is informed that one foundry is being persevered with, and that one pattern has not contributed anything toward supplies for a long period, he contends that a wrong policy is being followed, expressing the view that the pattern should be recalled and sent elsewhere.

On the other hand, should he be told that the pattern has been sent to three or four foundries and no results attained, it is certain that his views will be exactly opposite, for he will contend that the earlier foundries have not had a fair chance, and that, had the pattern remained in foundry B a little longer supplies would have been forthcoming. The buyer must not, of course, expect sympathy from such a quarter, for whichever course he adopts will be condemned. Success is the only thing which counts, and if he is not successful, it is useless to advance reasons or excuses. He has a difficult task to perform, and he must adopt the policy which, in his opinion, has the best chances of succeeding.

"A BUYER"

MARINE ENGINE CYLINDERS.—M. Guedras, writing in a recent issue of "La Fonderie Moderne," recommends the following composition for making large marine engine cylinders: C.c., 2.34 per cent.; Gr., 1.16 per cent.; si., 1.20 per cent.; Mn., 0.70 per cent.; S., 0.03 per cent.; P., 0.35 per cent. He states that such a composition is satisfactory from the point of view of casting and use.

Silica Bricks.*

The variety of properties required in silica-bricks results in many conflicting demands being made on the manufacturer. The quality of the brick is the product of many opposing factors, and between these a choice must be made according to the purpose for which the brick is to be used. Perhaps the most conspicuous instance is the difficulty of combining adequate density with the elimination of permanent expansion. For the steel furnace the relatively dense brick would appear to hold the field, but for many purposes where corrosion by slagging is no longer the main factor in durability it becomes possible to give fuller attention to the elimination of expansion; this is especially true of bricks for coke ovens. The manufacturer must therefore consider the purpose for which his bricks are to be used, and no single specification can be made to cover all the varied types needed. This has not been fully realised, and confusion has been caused by the assumption that the elimination of expansion is to be the main object of the brick-maker. It must be borne in mind that control of the process of manufacture is by no means fully developed. An attempt to improve one quality is apt to lead to deterioration in another, as, for example, when an increase in density is nullified by the development of spalling. But some advantage can generally be obtained by careful work towards the elimination of minor defects provided that the object in view is clearly specified.

The process of manufacture, although generally similar both at home and abroad, differs in detail from place to place. The main differences met with are connected with the composition and texture of the silica-rock employed, the method of crushing and grinding, the nature and amount of material added to form a bond, the method of moulding, and lastly the temperature and duration of firing.

Quartzites and siliceous sandstones that offer a considerable variation in both composition and texture are used for the manufacture of silica-bricks, but it is essential that they should possess granular structure and a high percentage of silica coupled with a low percentage of alumina and alkalies. The preparation of a brick of a specific refractory nature, with the requisite density, strength, porosity, and durability, is connected on the one hand with these characters, and on the other hand with the nature and amount of the added bonding-material. The production of the bond is aided by the interstitial matter of the crushed ganister, and this matter, together with the added lime, facilitates the conversion of quartz into those higher-temperature modifications of silica (especially tridymite) on which the refractory character and strength of the ground-mass of a silica-brick mainly depends.

In many British works the whole of the crushed ganister, after passing a screen, is used in the brick, and the aggregate and ground-mass are not separately graded. It is evident that no hard-and-fast distinction can here be drawn between the two; the exterior of the smaller quartz-grains is attacked and contributes to the ground-mass, while the interior remains unaltered; nevertheless, the greater part of the ganister is represented by the larger fragments, so that the burned brick may conveniently be described as an aggregate of ganister imbedded in a ground-mass containing numerous quartz-grains. In France much attention has been given to the grading of the material, and "impalpable" quartz from ball-mills has been used in the ground-mass so as to accelerate the development of the tridymite network

Silica Rock.—It is a well-established fact that the high-temperature stability of a silca-rock itself, as used in the aggregate, is diminished by an undue proportion of constituents other than silica, such as felspar, kaolin, etc. A rock, therefore, with small, closely-packed grains and a small amount of interstitial matter is likely to produce a more stable brick than a coarser-textured rock of similar composition when burned under the same temperature-time conditions. It is easy to understand, from these considerations alone, why the Sheffield type of ganisters has proved so eminently suitable for use as the aggregate in the manufacture of silica-bricks.

It may be accepted as proved that rocks of the Sheffield type are more easily converted into sound silica-bricks of required refractory character and stability than any other quartzites and sandstones, but it does not follow that rocks differing from this type in both texture and composition will not, under special treatment, furnish bricks of equal merit. In fact, moderately coarse-textured and pure quartzites, such as those of the Medina Formation, of which probably 85 per cent. of the American bricks are made, are manufactured into bricks of high quality. It must, however, be borne in mind that it is the practice to burn the bricks more completely in the United States than is customary in Britain. Similar remarks apply to Germany, where quartzites that differ considerably from our ganister type are used almost exclusively. In Britain the diversity of rocks used has given rise to a series of special treatments, and much empirical handling of the raw material, especially in such matters as the grinding, amount of added bonding matter, and the temperature and duration of burning. There are, however, certain principles which may be applied to all rocks alike, and which may be stated in general terms as follows:—

FIG. 1.—USED ROOF-BRICK. COARSE AGGREGATE OF TRIDYMITE AND MAGNETITE. ZONE B. × 30 DIAMS. ORDINARY LIGHT.

FIG. 2.—USED ROOF-BRICK. AGGREGATE OF TRIDYMITE AND MAGNETITE. ZONE B. MANY OF THE CRYSTALS OF TRIDYMITE SHOW THE CHARACTERISTIC ARROW-HEAD TWINNING. × DIAMS. CROSSED NICOLS.

The coarser the texture of a pure silica-rock, the smaller, within limits, should be the size of the rock-fragments produced by the crushing. The purer the silica-rock used in the ground-mass, the greater must be the proportion of added bonding material. The purer the silica-rock used in the ground-mass, and the coarser the grinding, the longer must be the time of burning for an equal degree of conversion, and, conversely, the finer the quartz and the more evenly distributed the impurities and the added bonding material, the more rapidly will the required changes take place on heating.

Bond.—To all silica-rocks in their crushed state or during the process of grinding, some foreign matter is added to form a bond on burning. In the majority of cases, this takes the form of milk of lime, although other materials have been used, either alone or with a proportionately reduced amount of lime. Aluminous compounds, in the form of clay, ferric oxide, slaked calcined magnesian limestone, and a number of artificial substances such as calcium chloride, aluminium sulphate, and colloidal silica, have been tried, with more or less success, but for general purposes lime seems to be satisfactory, especially when the silica-rock already contains a moderate amount of alumina and traces of other oxides.

The percentage of lime in a good silica-brick varies considerably according to the type of silica-rock used and the degree to which the crushing of the rock has been carried out, *i.e.*, the proportion of ground-mass in

* Extract from the Special Reports on the Mineral Resources of Great Britain. "Memoirs of the Geological Survey," Vol. XVI.

the brick. In the case of bricks made from the American quartzites, and other somewhat coarse-textured but pure quartzites, the percentage varies from 2 to 3, generally being about 2. The first effect of an increase is to render the brick more friable, while a further increase not only emphasises the friability, but progressively lowers the softening-point. In the case of our coal-measure ganisters, in which the impurity is greater and more evenly distributed, the quantity of added lime seldom reaches 2 per cent., while for quartzitic rocks that contain more alumina, ferric oxide, magnesia, and alkalies, 1 to 1.5 per cent. is probably about the right proportion. With rocks containing a higher percentage of impurity, the addition of only 1 per cent. of lime often makes a brick which is too friable for general use, while as much as 1.5 per cent. unduly reduces its refractory character. It would appear, therefore, that the percentage of added lime may vary within such limits as from 1 to 3. Efficient mixing of the lime with the rock powder is all-important, for the bonding material must be equally disseminated throughout the whole mass in order to produce a ground-mass of equal stability, and refractoriness throughout, with a maximum yield of tridymite. Further, it is obvious, that by thorough mixing and fine grinding, the proportion of added bonding material may be reduced and refractoriness thereby increased.

The effect of the added lime in aiding the conversion of quartz into the higher-temperature forms of silica has been proved experimentally by Seaver, who finds that in a lime-quartzite brick the amount of conversion is 77.35 per cent., as compared with 48.95 per cent. in the quartzite itself under the same temperature-time conditions.

If pure quartz and calcium oxide are heated together, they combine to form various calcium silicates of which the stable meta-silicate CaO. SiO_2, melting at 1,400 deg. C., and the less stable silicate 3CaO. $2SiO_2$ are those with which we are probably most concerned. The reaction takes place freely with pure components between 1,400 deg. C. and 1,500 deg. C., when the meta-silicate is formed, and this compound is capable, in the present of excess of silica, of forming an eutectic mixture which contains 37 per cent. CaO, and which will remain liquid to as low a temperature as 1,436 deg. C. It will be obvious, however, that the melting-temperatures of these pure compounds and even of the eutectic, are all well above those at which bonding occurs or, at any rate, commences in the burning of a silica-brick, and therefore the initiation of the process must be attributed to the presence of some other substance contained in the rock itself.

We have, therefore, to consider the effect of the presence of other bonding- materials beside lime. That usually present is alumina, which is generally derived from the rock used for making the ground-mass, but is occasionally added when required.

If lime and silica alone are present, combination may take place slowly on prolonged heating at low temperature—as indeed happens in certain cements below the melting-point—but it is not until the eutectic temperature, 1,436 deg. C., is reached that a liquid will make its appearance. In dealing with absolutely pure materials delay is sometimes met with in the combination of the two oxides which form the compound CaO. SiO_2, but in practice, on prolonged heating and with slight amounts of other impurities present, it is likely that equilibrium will be attained, as is evidently the case in ordinary silica-bricks. The eutectic contains the whole of the lime, together with sufficient silica to form 63 per cent of the melt. If it is assumed that the ideal brick contains 3 per cent. of CaO, the total percentage of eutectic melt at 1,436 deg. C. will be 8.1. The rest of the silica remains in the solid state, but undergoes regrowth to form tridymite; this is accompanied by a slight disturbance in the composition of the melt due to the greater solubility of quartz. In a pure lime-silica brick, then, the proportion of melt is small and the temperature at which it is formed lies very close to that at which the bricks are burned.

From a study of the Ternary Diagram for the system $CaO—Al_2O_3—SiO_2$, it would seem that the ideal might contain, say SiO_2 97, Al_2O_3 1.2, CaO 1.8 pr cent. In practice the presence of impurities will modify this composition, and it must not be regarded as in any way essential, but the example may serve to illustrate the considerations that underlie the selection of a suitable bond for silica-bricks.

Burning.—The effect of burning a raw silica-brick is two-fold; firstly, to produce a siliceous melt that will permeate the ground-mass and act as a cement, and, secondly, to convert as much as possible of the quartz in the ground-mass into a felted aggregate of tridymite-crystals, whereby the greatest permanent expansion is given to the brick and the refractory character is greatly increased. The production of the siliceous bond has already been discussed; but the conversion of quartz, on which so much has been written lately, also leaves much room for experiment and research.

A study of thin sections of burned bricks and also of bricks that have had prolonged use in a furnace, shows that the conversion of quartz begins mainly at the outer surfaces of the quartz-grains, those surfaces being either the original boundaries of the grains or the result of fracturing by grinding or thermal expansion. Further, we see that after a brick has been burnt at a temperature well above that at which quartz is supposed to change its crystalline state, and even after its long-continued use in a furnace, much unconverted quartz still exists in the cores of the grains. It would appear that the conversion takes place more readily in quartz that is in contact with the siliceous melt, than in that which is free from impurity of any kind. It may be taken as established that after its initiation the progress of conversion rapidly diminishes in velocity, so that it is only with a steady rise in the temperature of the kiln towards the melting-point of quartz that a higher degree of conversion can be obtained.

For a successful brick it is desirable that the permanent expansion attendant on the conversion, which theoretically exceeds 13 per cent., should be as far as possible accomplished in the kiln, and that no undue further expansion should take place in the furnace. By this we do not mean that all the quartz must be converted, but that the brick should be brought in the kiln to such a state that further conversion may be so slow and the attendant permanent expansion so small as to cause no inconvenience. Viewed solely from the aspect of refractory character and permanent expansion, it is, of course, desirable that as much as possible of the original quartz of the raw brick should be converted, but practically the main consideration is the amount that can be converted in a reasonable time with a reasonable consumption of fuel and without damage to other properties essential to the brick. According to Seaver, a lime-silica brick burned for forty hours at 1,540 deg. C. had 77.35 per cent. of its quartz converted; a second burning of like duration and temperature raised the percentage to 82.87, while a third raised it only to 83.98. From this it may be deduced that the maximum charge takes place in the first burning, and that a state is reached in which, although unconverted quartz is present, its rate of conversion and the consequent expansion are so slow and small as to be readily dealt with. Similar experiments carried out by Seaver on the silica-rock showed that a much lower degree of conversion was reached on the first burning, only 48.95 per cent., while the second gave 68.62, showing how much more slowly and more steadily the change takes place without the addition of material such as lime, which, with the impurities already present, is capable of forming at a reasonably low temperature a sufficient volume of melt to permeate the brick. Further, from the above, it will be seen that the presence of large grains or fragments of homogeneous quartz will delay and lengthen out the process of conversion, and thus correspondingly lengthen the time during which the brick will be subject to permanent expansion. If, on the other hand, the ground-mass is made with finely-ground silica, the chief expansion will occur rapidly on firing, and will be succeeded only by the slow conversion of the ganister-fragments.

It is commonly stated that British bricks are not sufficiently burned. There is sometimes truth in the criticism, but as the temperature and time required for burning must of necessity vary according to the method of manufacture of the "green" brick and the purpose for which the brick is required, no definite rules can be formulated. If permanent expansion in furnaces is to be avoided, a dense brick will certainly have to be fired more completely than one of open texture, for in a porous brick some of the expansion consequent on reheating may be taken up by the interstitial spaces. Further, a brick with much siliceous meal will convert more rapidly and more completely than one in which the quartz-fragments are larger. Improvement may therefore be effected by judicious choice of texture rather than by increasing the temperature and time of burning.

In the important stage of the initial burning the results are influenced by the rate at which the temperature of the kiln is raised. It is an advantage to heat slowly up to 800 deg. C., at which temperature the quartz-conversion itself may first begin; and again, above this, slow increase may be expected to ensure the more complete and economical conversion of quartz and the production of the stronger brick. Moreover, the slowness favours the formation of larger crystals of tridymite in the matrix, and these, by their angularity and interlacing, add to the stability of the brick. This effect is well exemplified by the used brick, in which the crystals of tridymite attain relatively large dimensions, as shown in Figs. 1 and 2. That the conversion should be started and carried out at as low a temperature as possible is desirable. Rapid rises or falls of temperature tend to produce an undue amount of glass and to set up strains or actual planes of weakness in the brick.

XUM

Permanent Moulds for Cast Iron Castings.

The extensive and successful use of permanent moulds or dies in the production of castings in non-ferrous metals and alloys has re-directed the attention of ironfounders to their use for the production of castings in cast iron.

The present day conditions of costly labour charges and scarcity of skilled moulders is perhaps the most important contributory cause in the revival of interest in this permanent mould question, and recent advances in engineering construction have resulted in widening the demand for high grade castings, which it is hoped that the use of permanent moulds will satisfy. Apart from the actual labour costs in production of sand castings the most fruitful source of additional expense is the percentage of wasters, and in spite of all that is said to the contrary by far the greater proportion of waster castings can be traced to defects in the actual moulding operations, which in their turn must necessarily be attributed to lack of skill on the part of the individual craftsman. Very probably in no other branch of the engineering industry does the personal skill of the individual worker enter so much into the cost and quality of the finished product as in the foundry industry. The condition of the sand and mould, the accuracy of the mould and core construction, the relative position of the cores and the success of the means taken to prevent their movement are amongst the features which are entirely the concern of the individual moulder and which all have an important bearing on the success or failure of the finished casting.

The extensive adoption of permanent moulds has always been looked up to as a means whereby defects and wasters from these and similar causes might be eliminated.

As in the case of non-ferrous metals, attention has been largely directed to the use of metal for the construction of the permanent moulds or dies. By virtue of the considerably higher thermal conductivity of metal over sand the use of metal for this purpose results in a considerably increased rate of abstraction of heat from the molten metal and the casting thus cools at a considerably quicker rate. Obviously, the rate of cooling has a very marked influence both upon the character and also the chemical constitution of cast iron, and the quicker the rate of cooling the finer the crystal structure and consequently the closer grain shown on a fractured surface. With extremely rapid rates of cooling, cast iron generally shows a white, hard crystalline fracture indicating that the whole of the carbon has been held in combination and prevented from dissociating with the consequent production of free graphite. This phenomenon is, of course, familiar in the production of chilled castings having an intensely hard white skin, such as, for example, chilled rolls and crusher jaws.

It is generally accepted that the closer the fracture of cast iron the higher the tenacity. Experience goes to prove that grey cast iron, cast in permanent metal moulds and having an extremely close grained structure is of considerably higher tenacity than the same material cast in sand. The following results were obtained on test bars cut from the centre of a large ring casting of the cross-sectional dimensions 8 in. by 6 in. Test bar A was cut from a casting produced in a permanent mould and test bar B from a similar casting produced from the same metal by the ordinary sand moulding process. Test bar A gave a tensile strength of 14.22 tons per sq. in., and a Brinell hardness number of 235, whilst B only gave 9.42 maximum stress and 156 hardness number. The chemical composition of A was comb. carbon 0.34 per cent., graphite 2.77 per cent., silicon 2.23 per cent., manganese 0.62 per cent., sulphur 0.03 per cent., phosphorus 1.03 per cent., and B was comb. carbon 0.14 per cent., graphite 3.19 per cent., silicon 3.03 per cent., manganese 0.48 per cent., sulphur 0.07 per cent., phosphorus 1.39 per cent.

Some further figures in support of the increased tenacity obtained by the use of permanent moulds have been obtained by the Daimler Company, Limited, on piston ring sleeve castings produced in permanent moulds. The average results for sand and chill casting were as follows:—Sand castings, 16.66 tons per sq. in.; chill castings, 20.51 tons per sq. in.

Dr. Moldenke, in the discussion before a recent meeting of the American Society of Mechanical Engineers, stated that he found that castings made in iron moulds were not as strong as those made in sand moulds. He considers that by the use of iron moulds the molten metal is cooled so rapidly as to set up internal stresses, which it is to be presumed are responsible for the reduced strength values. No definite figures in support of this view are yet to hand, but Dr. Moldenke considers that research should be directed with a view to producing moulds of a permanent nature from refractory materials rather than metals. The idea underlying this suggestion may be probably that of the reduction of internal strains by virtue of the slower rate of cooling or the less risk of the presence of chilled spots and corners which are one of the great difficulties encountered in the production of cast-iron castings in metal moulds.

With the exception of Dr. Moldenke's opinion all the evidence at present available points to the fact that the use of permanent metal moulds results in an increased tenacity in the iron casting over a casting produced in sand of the same chemical composition.

In view of the considerable advantages to be obtained by the use of permanent moulds it is of considerable importance to consider the reasons underlying their comparatively slow progress in the foundry industry of this country. These reasons can be considered under two headings—(1) the commercial reasons, and (2) the metallurgical reasons. From the commercial point of view the production of the actual metal moulds for all but simple castings involves a heavy initial expenditure not only on the production of the mould itself but also on initial experimental work invariably entailed before a satisfactory mould can be properly designed. Obviously it is only possible to recover this initial expenditure and produce castings at competitive prices at the same time, when the number of castings required from the mould is sufficiently large. This is a matter for the consideration of those who have to do with the designing of castings. The second feature of considerable commercial importance is the life of the mould material. In the case of permanent moulds for use in the production of castings in the low melting-point non-ferrous alloys, where the temperature conditions are not nearly so severe, the life of the mould is not nearly so vital a factor. With properly prepared moulds cast-iron will usually last sufficiently long to make its use profitable. In the case of permanent-mould castings in cast iron, however, the temperature conditions are more severe, and even with carefully prepared moulds of special cast iron growth eventually sets in and ultimately ruins the mould either by surface disintegration or by causing the premature cracking of certain parts of the mould. This aspect of the question is quite a serious one, and as yet there is no generally known method of satisfactorily overcoming this difficulty.

In the case of certain simple moulds, such as are used in the production of straight cylindrical rods or plain small castings, as many as 5,000 castings are stated to have been obtained from a single mould. In the case of aluminium bronze, in which the temperature conditions are of a similar nature to those involved in cast-iron, Messrs. Rix and Whitaker* (1) stated that in their experiments the mould life was approximately 7,000 to 8,000. The most important feature in controlling the life of cast-iron dies would appear to be the temperature attained by the die during operation, and providing this does not exceed a temperature of 650 deg. C.. there should be very little difficulty in obtaining a sufficiently long life, to render the use of permanent moulds profitable even in the case of these high melting-point alloys.

The great bar to the extensive development of die-casting in cast iron lies in the metallurgical problems involved. The most important of these problems is the difficulty of preventing chill in the castings. The presence of chilled white iron spots, corners, or edges in castings are absolutely fatal in castings requiring to be machined, and engineers and machine-shop managers dread the occurrence of such defects.

As is well known, when cast iron of a given composition is cooled with sufficient rapidity the whole of the carbon is retained in combination as the carbide of iron and its structure consists of the iron-carbide eutectic with more or less saturated austenite according to the composition of the particular iron. This structure is almost glass-hard and unmachinable by any ordinary means. If, on the other hand, the rate of cooling is sufficiently slow or the composition of the iron is modified by, say, a increase in the amount of silicon, then the carbide of iron is dissociated with the formation of free graphite, and the resulting casting is grey soft and readily machinable.

The production of grey machinable castings in cast iron from permanent moulds is therefore governed entirely by the composition of the iron and the rate of cooling in the mould, and with any given composition it is obvious that the rate of cooling is the controlling feature. Broadly speaking, the rate of cooling is a function of the two factors—the initial temperature of the metal and the temperature of the mould—and it will be obvious that with any given temperature of metal the rate of cooling will depend upon the temperature of the mould, and the greater this difference in temperature the quicker the rate of cooling. By casting in moulds at a sufficiently high

* "Journal Institute of Metals," 1918, No. 2.

temperature even very low-silicon irons can be produced quite grey.

It is, however, not an easy matter to control the temperature of the mould, particularly if a very high mould temperature is desired, and, further, the maximum temperature which might be obtained in moulds as a commercial proposition is limited by other features, such as the life of the mould. It is therefore the general rule to aim at obtaining an iron with a sufficiently high silicon content, that with the particular mould temperature normally obtained with the particular rate of casting in operation gives a grey iron. It will readily be appreciated that considerable latitude is possible in the degree of control which might be exercised. The temperature attained by the mould with any given rate of casting can be modified by varying the thickness of the mould, and any variation in this thickness can be counteracted by a suitable variation in silicon content.

With simple straight castings of a fairly large cross section very little difficulty is experienced in the production of castings free from chill. In castings of fairly thin cross section it is very frequently experienced at the corners and edges and rapid changes in contour. This is so important that one American writer has stated that, broadly speaking, it is impossible to produce permanent-moulds castings on this account, and it is highly probable that this feature is one of those reasons underlying Dr. Moldenke's plea for the use of some form of refractory material for the construction of permanent moulds.

This fact is, however, real, and those who have any experience in attempting to produce permanent-moulds castings in cast-iron are generally in agreement that this is the most important feature in retarding the development of this class of casting.

The easiest way out of the difficulty is annealing, and this has been resorted to by several people. By the use of properly designed furnaces for the purpose of annealing and the adoption of systematic methods of handling the castings, a large amount of the initial heat in the casting can be conserved. Furnaces of this type are virtually soaking pits. It would appear on the face of it that the adoption of some standard annealing process would also be doubly advisable for the purpose of removing the internal stresses due to the rapid cooling of the metal.

Tempering Sand.

Under this heading, the "Foundry World" discusses the necessary amount of moisture which moulding sand should contain to properly temper the material.

How much water is required to temper sand is a question that has been under discussion ever since foundrymen commenced to look into the practical details of their trade.

Moulding sand is composed of fine grains of silica, with a certain amount of clay that acts as a bond or binder. Tests have shown that the best moulding sands are composed of grains of sand of approximately uniform size, and that the best clay must be in the nature of what the potter calls a fat clay and what the chemist calls a highly colloidal clay. A clay in this condition has been changed by organic or plant matter in the soil in such a way that it has associated with the mineral constituents of the clay a large amount of water, which is chemically combined with the mineral matter. When such matter is exposed to heat, as in pouring the castings, a certain amount of the moisture is expelled, and the clay will not regain its full binding power until this has been replaced. It is well known that when a dry sponge is put into water it takes a certain amount of time for it to absorb the moisture. The same is true of colloidal clay. This explains why it is that it takes a definite length of time to temper moulding sand. In other words, there has to be sufficient time for the moisture to sweat through the sand and be taken up by the clay, and thus bring the clay to its best bonding condition.

For brass moulding a very fine sand is used, such as No. 0 or No. 1 Albany. This means that in a cubic inch there are a certain number of sand grains. For steel moulding a very coarse sand bonded with fireclay is used, and in a cubic inch of such material there may not be over one-eighth as many sand grains as in the fine Albany brass sand. If the moulding sand contains clay acting as a bond between the grains, and this clay in turn has to have a certain amount of moisture, the total moisture required is to a certain extent directly proportional to the number of contact points between the sand grains, and hence the fine brass sand will require much more water than the coarse moulding sand. Practice proves this, and in the case of certain coarse steel foundry sands less than 3 per cent. of moisture is required to properly temper the material, while in certain very fine brass sands over 10 per cent. of moisture may be required.

The moment that the necessary amount of moisture is exceeded there will be present in the sand certain water which is not absorbed by the clay, but which is present as free water between the sand grains. The trouble with this free water is that when the casting is poured, any water held by capillary attraction between the grains and not absorbed by the clay is much more readily acted upon by the heat, and will cause blows more quickly than that which is associated with the clay.

In the case of a fine moulding sand the excess of water causes a sudden generation of steam, which in turn disturbs the surface, momentarily isolating grains on the face, and giving these grains a chance to burn into the face of the metal. Hence too wet a sand always results in a rough-faced casting. On the other hand, too dry a sand may result in cutting the face of the casting by the flowing metal, and this also gives it a rough surface.

Modern Core Making.

In our issue of January 13, Mr. Feasey, of Lincoln, gave some details of the foundry of the Nash Motor Company, of Kenosha, Wisconsin. The January number of "The Foundry World," the house organ of Messrs. H. M. Lane Company, of Owen Building, Detroit, Michigan, supplements this by two illustrations shown in Figs. 1 and 2.

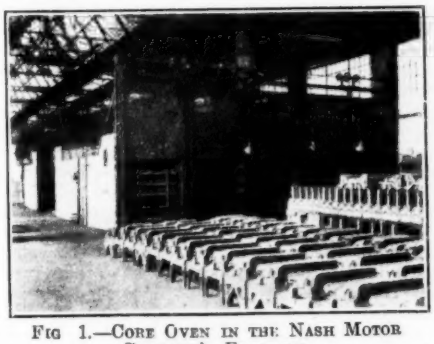

FIG. 1.—CORE OVEN IN THE NASH MOTOR COMPANY'S FOUNDRY.

Fig. 1 shows two double batteries of core ovens which are fired from outside the building, the firing pits being placed under the railway track where they can be readily supplied with fuel. The ovens are of the rack type, and the introduction of this method of handling cores greatly reduces the labour in the core-room.

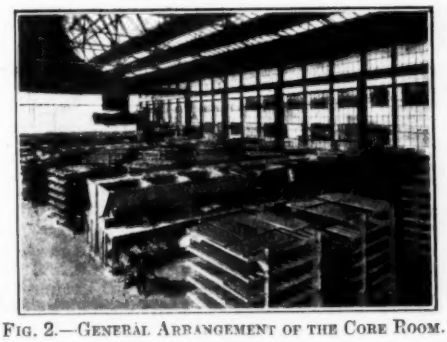

FIG. 2.—GENERAL ARRANGEMENT OF THE CORE ROOM.

The general arrangement of the core-room as finally equipped is shown in Fig. 2. The sand mixing unit is placed at the back of the building near one side wall and suitable arrangement made with mono-rails and a crane for supplying sand and for handling materials and supplies. The plant was originally equipped with a mono-rail system for handling metal and other supplies.

The good lighting conditions in the shop can readily be appreciated from the view shown.

MR. W. H. SHERBURN, of Stockton Heath, has retired from business after long, active association with the Richmond Gas Stove & Meter Company, Limited, of Warrington and London. The occasion was celebrated by the presentation by Mr. J. W. Slack, on behalf of the directors and staff, of a massive chiming timepiece, together with a silver cigarette case to Mr. Sherburn and a gold wristlet watch to Mrs. Sherburn as marks of esteem, all the presents being suitably inscribed.

Refractories in Moulding Practice.*

By Mr. H. Winterton.

This paper is not intended to be an academic discussion on the various uses of refractories, but on a subject which, though formerly accounted as of but little worth, of late years has slowly but surely presented itself to foundrymen generally as a matter deserving no little thought and quite a considerable amount of care.

The lecturer briefly considered the meaning of the title of the paper. He thought Dr. Stansbie, in his thoroughly practical work, "Iron and Steel," defined the subject quite aptly and very clearly. This definition states that "refractory materials used for metallurgical purposes may be defined as bodies that can be exposed to the furnace temperatures for which they are used without softening or disintegration." This sums up in a sentence the whole secret of foundry refractories.

Generally speaking, foundry refractories may be divided into three classes, viz., acid, basic and neutral. The first-named are usually of service in steel foundries and the two latter in iron foundries. Included in the former are various silicates, whilst in the basic section are magnesite, bauxite, and other materials of a like nature, some of them far too expensive to be thought of in connection with castings for one moment. Graphite should be considered a neutral refractory, as it is neither basic nor acid.

Before leaving the general question of refractories one point was referred to which is not always recognised by foundrymen. It has reference to the siliceous refractories, of which large quantities are in use. Practical men have sometimes found that acid-forming oxides, when heated and in contact with basic oxides, unite with them to form salts, usually silicates, which, though in some proportions more fusible than the silica itself, yet on being mixed in other proportions have their fusing point raised, and are thus at once rendered of a higher commercial value for the purposes under consideration. These exact proportions are not discovered without much patience and experiment, and even then the end of the task is not reached, for varying castings of different densities require special treatment in their manufacture.

These remarks respecting silica refer principally to steel-foundry practice, but not a few iron-founders occasionally make use of acid refractories when confronted with a huge mould which has to be cast at a great heat. The practice is, however, not general, and, so far as the author has been able to ascertain from careful inquiry, is not very likely to be much adopted. Possibly, one reason for this is the ever-varying proportions of the silicates upon which founders have to rely. Undoubtedly the steel moulder is very conservative, but he is no more than ordinarily averse to change when shown that by some comparatively new method he can increase his output and at the same time improve his work. He is perhaps impelled to use more than ordinary caution by the very nature of his task. An example is shown by the position of affairs when war broke out in 1914. For many years a large number of steel foundries had obtained their sand from Belgium, and at first it was thought no efficient substitute could be found. Close research, however, was carried out on British silica formations, and it is interesting to note that not only was the British product found to do the work as well as its foreign competitor, but that it could be produced cheaper. At present many firms have signified their intention to carry on with the home product. The steel moulder cannot give too much attention to the all-important question of refractories, as his work is carried out at a much higher temperature than that of the iron founder.

Ordinarily, the question of the refractoriness of sands used in iron foundries is not sufficiently considered. In the past it has been customary for one of the youngest boys to be entrusted with the task of daily producing enough sand for the work of his mate, neglecting entirely the nature of the job. The porosity of the sand, its properties in relation to silica, oxides, or alumina were phases of the question which never troubled the lad, and the resultant day's output must necessarily have been disappointing.

The connection between the refractories and the moulding sand is easily traceable. Coal-dust is used because if the sand were unsupported the molten metal would fuse the surface, resulting in a rough blemished casting. This fusing is caused by the alumina and oxides necessarily present in the sand as binding agents. The oxidation of the coal-dust causes the presence of carbonic oxide or carbon dioxide gas, and this provides the necessary protection when the metal is in a molten condition. Not only, therefore, is it necessary that care should be taken in the selection of the sand used in the foundry, but it is equally essential that the supply of coal-dust should be carefully watched. The porosity of the sand and the weight of the finished casting are important factors for determining its purpose, whether for suitable machining or not, which should also be considered by the foundryman. In selecting coal-dust for use in the foundry care must be taken to inquire into its bituminous qualities, its ash and volatile contents, and its proportion of fixed carbon. It is not intended to lay down a fixed rule with regard to these various constituents and their proportions, for experience has taught that few men think alike on this subject. Obviously too great a proportion of ash is most deleterious, and can only result in castings having a whitey-grey appearance, with a particularly rough surface, and probably sand-burnt. On the other hand, if a coal of too high a carbon content be used, with a necessarily low ash percentage, the facing becomes of too refractory a nature, and the coal-dust is unable to carry out the functions for which its application was intended.

Another matter of importance is the "grist" of the coal-dust. If it is important to control the porosity of the sand, surely it is equally important to consider the "grist" which the men have been accustomed to use for different tasks. It is necessary to vary the "grist" according to the class of casting required, and of the grade of sand used. This is a feature which is not always accorded the attention it deserves. For very light castings a coal-dust of an exceedingly fine mesh is desirable; especially if the sand is "open," whilst a slightly coarser, yet still fine, "grist" should be used for heavier work. The medium and coarse grades will be required for the larger classes of castings, in which it is necessary for the generated gases to be carried away quickly. The provision of a skin to the casting is left to a large extent to the blackings, which are referred to in the next section.

Superfine coal-dust is essential for light castings; this has been proved by many successful experiments. On account of the lightness of metal, the gases have not been overwhelming, and the comparatively low temperature of the light body of iron has been sufficient to fuse the minute coal particles, and thus give a fine surface accompanied by easy stripping.

When coal-dust of too coarse a grade is used, small "pits" are left on the face of the casting when cooled, and these are easily distinguishable by their formation from those indentations caused by particles of sand insufficiently milled. Gas in excessive quantities—excessive in consequence of the size of the particles—takes the line of least resistance, viz., the soft molten metal, resulting in "pitting," which is too frequently seen in the finished article. Where larger castings are concerned, the heavier weight of metal, and the consequent increase in temperature, prevents such indentations, particularly as the coatings of blacking on big moulds are generally more pronounced.

After stating that there are several good designs of British sand mixing machines on the market, the author stated that few will be found to do the work better than a "hefty" labourer with a shovel and the knowledge of how to make the use of it effective.

* Paper read before the Birmingham Branch of the Institution of British Foundrymen.

Undoubtedly there is a wide divergence of opinion as to the uses of blacking, whether for loam, dry sand, green sand, or cores. Blackings or facings may be divided into various classes and sections. The old fashioned idea of blacking moulds with all types of compounds, many of them of doubtful efficiency; some are most evil smelling, and not a few positively deleterious to the casting. A recommendation in a treatise on foundry practice is to mix coal-dust as a facing. The adoption of this advice will undoubtedly result in surface trouble. The modern foundry demands various facings suitable for the particular class of casting upon which it is engaged, consideration being given to the thickness of metal, the heat of the molten iron, and the general characteristics of the finished casting. Hence, it has been established that for light castings nothing exceeds in efficiency a charcoal blacking of good quality, though expert practical men are not quite in agreement as to whether a pure wood charcoal or one slightly stiffened with a mineral admixture produces the better results. Two light casting foundries, however, have mixed a special facing to their own formula, and even these differ to a marked degree in essential particulars. It is certain that both these foundries enjoy a high reputation for the excellence of their castings, whilst the proprietor of one asserts that since introducing the new method he had experienced far less trouble in the fettling shop and had effected a considerable economy in that department. For ordinary green-sand work which requires "sleeking," there are now prepared many mineral blackings which assist to bring out on the casting a blue glossy skin, so much sought after by founders. The true functions of facings are reflected by this very anxiety of the founder. He knows that given a good highly refractory substance the pores on the face of the casting will be closed up, and therefore the utility of the skin does not end with the colour. He knows, too, with a blacking of the right character the fettling of the casting is a matter of comparative simplicity. This remark applies not only to green sand but also to loam, dry sand, and core work. It is necessary to have a stronger or heavier facing for the larger castings, because not only has the weight to be considered but the casting temperature in large mouids becomes a serious factor. Hence, it is necessary to provide a strong refractory in which the percentage of carbon grows higher in accordance with the strain sought to be put upon it. It is here that theory does not apply, but where it does research becomes necessary.

From the previous remarks it might be understood that to get good results consistently it would only be necessary to raise the carbon content. But this is not all that is required. Some refractories are of so harsh a character as to preclude all thought of "sleeking" on a green-sand mould or mixing with water or clay wash in a boss, especially when newly prepared. It is here that the skill of the blender is required, and by his agency various facings are produced which can be held to cover all classes of moulds.

In many instances it has been found that the slightest modifications of mixtures have made all the difference between a good-looking casting and an indifferent one. Trouble will result if a facing does not possess refractory characteristics to a high degree, when facing a mould of considerable size, which is to be cast at a high temperature. On the other hand, the presence in the blacking of too great a proportion of siliceous matter would cause excessive scabbing and burning. But as previously indicated, the use of a high refractory for light castings is not usually advisable. For cores a sound refractory must be used, but the necessity of providing something that will not easily rub off after baking must be kept clearly in view. Here again the task has been to provide an article which will perform its work perfectly under varying circumstances.

Graphitic facings may be divided into three classes—plumbago, graphite, and blacklead. There are very many qualities, but it is more or less again a matter of carbon content, and founders who are satisfied with the commoner kinds must not expect to obtain such good results as others who endeavour to procure the highest grades. Here once more the question of individual practical test comes to the front.

During the war many founders discovered to what a large extent we were dependent upon overseas possessions for the provision of some of the grades of plumbago. Several cargoes on the way to this country from Ceylon were intercepted by German submarines and sunk. As a result of war shortage the shipowner discovered the utility of the article which he had been previously carrying at a low rate, and as a result the freightage on plumbago has risen more than on the majority of commodities. Obviously a return to pre-war costs in the matter of refractory compositions, incorporating plumbago, must necessarily be impossible.

The Lumsden Oscillating Surface-Grinder.

The first of this type of machine has now been demonstrated in the Lumsden Works, and appears to be a very satisfactory design of machine for work that comes within its capacity. Alfred Herbert, Limited, Coventry, as sole distributors for the Lumsden line of machine-tools, are placing the machine on the market.

The machine finds its chief field in the locomotive, shipbuilding and general engineering shops, where products such as steel railway buffers, axle boxes, axle box covers, cast-iron boxes require to have plane surfaces up to, say, 24 in. by 10 in.

The grinding wheel head is mounted on a very substantial swinging arm, whose base consists of two trunnions, which are each supported by a broad bearing on a shallow box section bed. The arm is free to oscillate about the centre of these bearings, the movement being obtained by a connecting rod operated by a crank on a three-speed gearbox which is fixed to the bed of the machine. By adjusting the throw of the crank the stroke of the oscillating arm on the radius of the grinding wheel centre can be varied from zero to a maximum of 24 in. The grinding wheel head consists of a 16-in. segmental cup wheel, with 8 segments, mounted on a ball-bearing spindle carried in a ram,

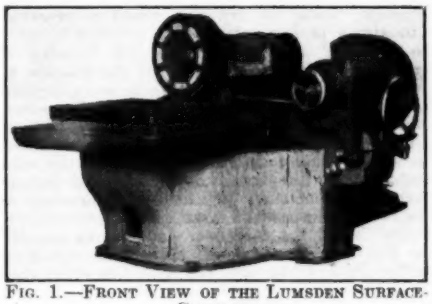

FIG. 1.—FRONT VIEW OF THE LUMSDEN SURFACE-GRINDER.

which has an adjustment parallel with the axis of oscillation of the swinging arm. This adjustment, which is for feeding the wheel to the work, is controlled by a handwheel on the gearbox, and can be operated when the arm is in motion. The wheel segments are 6 in. long and can be used down to a length of 2 in. or even 1½ in. if special care be taken in chucking them. The spindle drive is by belt from a self-contained countershaft, which is situated on the centre of oscillation of the swinging arm, and is supported by bearings in the trunnions and also by a bearing on the bed. Facing the grinding wheel head is a tee slotted work table, which is surrounded by a cast-iron trough. An ample supply of water is provided by a pump driven off the countershaft.

There are three speeds of oscillation suitable for different lengths of wheel stroke, ranging from 43 strokes per minute for strokes up to approx. 8 in. to 10 strokes per minute for strokes from 16 in. to 24 in.

The whole machine is self-contained with ball-bearing driving shaft and wheel spindle.

With regard to production the following work has already been accomplished on the machine:—

Steel Railway Buffers.—Grinding plane surfaces 13 in. × 9 in. removing 1/16 in. in 2 mins. each.

Axles Boxes and Axle Box Covers (steel castings).—Grinding ¾-in. rim size 11 in. × 9 in. removing 1/16 in. in 1½ mins. each.

Cast-iron Boxes.—Grinding 1½ in. rim, size 12 in. × 12 in. removing 1/10 in. in 3½ mins. each.

THE JOHN FRITZ GOLD MEDAL, an honour in the bestowal of the four leading American engineering societies, has been awarded to Sir Robert Hadfield for his invention of manganese steel.

Gas-Engine Castings.*

The Rathbun-Jones Engineering Company, Toledo, O., specialises in the production of high-grade gas and oil engines up to and including 1,000 horse-power. The castings are made, machined, assembled, set up, and the complete engine tested to its full capacity before despatch.

All of the castings are poured in dry-sand moulds, as practically half of the casting losses in foundries are directly traceable to wet or unevenly mixed sand. The initial cost of a dry-sand mould exceeds that of one made in green sand, but an ultimate saving is effected in the percentage of good castings secured. This is particularly true of the castings that have to withstand steam, gas, or water pressure, or of castings on which there is a considerable machine finishing. The employment of dry-sand moulds eliminates, to a great

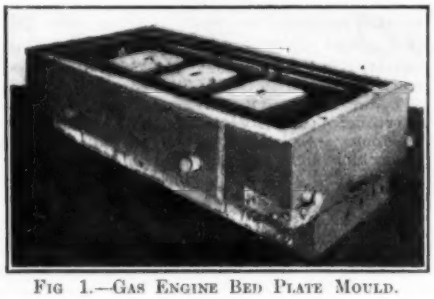

FIG. 1.—GAS ENGINE BED PLATE MOULD.

extent, segregation and shrinkage in the interior of the casting, as well as imparting to the outside of the casting a much better skin than it is otherwise possible to secure.

A mould that has been properly dried will not drop, blow, scab, or wash in front of the iron. This does not mean that satisfactory castings cannot be made in green-sand moulds, for thousands of such castings are made every day. It simply means that a certain amount of risk attaches to the making of every green-sand mould, while the dry-sand mould is practically sure to give a perfect casting.

The drags of all the flasks in this foundry are designed to facilitate the drying of the moulds, and are provided with bars, bottom plates being dispensed with. The last part of a mould to dry under ordinary circumstances is the bottom, owing to the fact that it is protected from the heat. A considerable amount of the steam generated in higher parts of the mould is condensed on its passage downward, and increases the amount of moisture in the sand forming the bottom. In the case of large cores it sometimes is necessary to roll the core over and remove the plate before the sand can be dried. When the moulds are placed in the oven to dry, the heat has equal access to the bottom and top, and the result is that they are dried more evenly and in much less time than if a bottom plate was attached.

The flasks for the bed plates, one of which is shown in Fig. 1, are designed to hold a minimum quantity of sand. Several sizes of these castings are made, and while they all possess the same general characteristics, the details of moulding vary to a certain extent. They are all moulded flange up, that is, in the reverse position from the one they will assume when assembled and in operation. In the smaller sizes no cope is employed. The lightening cores around the side are supported on stud chaplets resting on the bottom face of the mould. The main cores in the centre cut through and rest on the bottom also. The points where they join the sand in the drag form the openings for the driving rods of the engine. After the drag has been finished, dried, and cored, four slab cores are lowered on the drag in place of a cope. These cores may be held down by a row of binders, or, in some cases, a cope is set on. In the latter case the binders are wedged beneath the bars of the cope, which is rammed full of sand.

The larger engine beds, those ranging in size from 300 to 1,000 horse-power, are poured at both ends, but the smaller sizes are poured only at one end. Two runners are employed, the metal entering the mould through narrow gates near the bottom. Some of the beds are designed with a deep bead or groove around the face of the casting that is moulded down. The groove in the casting means a projecting body of sand in the mould. It is customary to ram a piece of dry-sand core at the two points where the stream of metal from the gates first enters the mould. The groove formed of the same dry-sand facing as the remainder of the mould and reinforced with a few nails would be considered amply secure by the majority of foundrymen. The piece of dry-sand core makes it absolutely secure.

Fly wheels, blank gears, and other work of a similar character are made in a flask, the cope of which is cast in one piece with the exception of an opening in the centre. Separate bars are wedged or bolted in this opening to accommodate any size or shape of hub. The method of pouring the wheels differs in this shop from the generally accepted practice. Instead of pouring them through the hub with one or two runners, they are poured between two of the arms about midway between the hub and the rim. A single upright runner is used, and a branch connecting the two arms is cut at the joint. It is claimed that this method of gating gives a cleaner casting than where they are poured directly on the hub. Feeding risers are placed on the hub and rim as usual, and the castings are fed after they are poured.

The drags for these flasks are made of a number of sides bolted together. Some of the advantages claimed for this method of constructing a flask are that the pattern making and moulding involved in making the flask parts are simplified. The ordinary pattern maker is quite qualified to make a section of a pattern that can be moulded and cast on its flat in open sand, as is done in making the sides for flasks. Another point in favour of the built-up flask is that, if necessary, thickness pieces can be placed between the joints of the different sections, thus making the flask considerably larger.

The cores are divided into two classes: stock, thin delicate and jacket cores are made from sharp sand bonded with an oil binder in varying proportions; and all other cores are made from a mixture of old and new sharp sand, bonded with glutrin. The sand employed is of an open and free-venting character, and in a great many instances no artificial aid is necessary to carry off the gases. Some of the cores, however, are almost completely surrounded by iron when in use, and it is necessary to provide channels in the interior of the core to facilitate the escape of the gas through one or more core prints. This feature is provided for by placing a number of wires or small rods in the core-box before it is filled with sand. After the core has been rammed, these wires or rods are withdrawn. In the case of the jacket cores, transverse channels are scooped in the sand and filled with fine coke. The coke vents embrace all the rods the entire way across, and converge toward the two prints on each side of the core. The rods are pulled out through the end

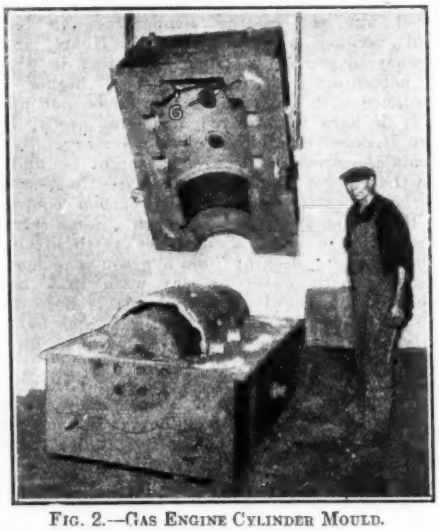

FIG. 2.—GAS ENGINE CYLINDER MOULD.

of the box after the core has been rammed and the bottom plate set on. Sometimes this is done before, but generally after the core and core-box have been rolled over. After the core-box has been lifted off, the holes in the end of the core are stopped by the finger and sleeked over.

All of the cores receive at least one coating of blackwash, and some of them are coated several times. The blacking employed is not of the usual character of that used on cores, but is the kind which is generally put on moulds, and known to the trade as silver lead. When the castings leave the sand, the skin is perfectly clean, both inside and out. No castings are lost on account of dirt gathered in the mould and held in suspension by the iron. A typical mould for one of the gas-engine cylinders is shown in Fig. 2. It will be noted that the cope and drag halves of the flask are alike, and no bottom board is used. These flasks are made with semi-circular openings in the ends, but

* Extracted from a recent issue of "The Foundry."

when in use one end is stopped with an iron plate provided with a number of holes, as shown. The flasks are elevated about a foot at one end before the mould is poured. A runner is situated on each side, close to the core print at the low end of the mould. The gates are cut into the core print as shown at *G*, Fig. 2. One large riser is taken off the flange in the upper end of the mould. The cylinders are poured from a semi-steel mixture, and the large riser is used for a feeder after the casting is poured.

Chaplets are dispensed with in making these castings. The main or centre core rests on a print at each end of the mould. One end butts against the end of the core print, but the other end extends through the open end of the flask. A certain amount of the vent escapes through the closed end of the mould, but the greater amount finds its way out through the unobstructed end.

The jacket core is heavily reinforced with a double set of rods running at right angles to each other. It is held in place by two branch cores on either side at the joint line of the mould, and is supported top and bottom by two short pieces of round core attached respectively to the face of the mould in the cope and drag. These short pieces of core are dropped into place while the mould is green. A little paste is placed in the print, then the core is introduced, after which the sand is tucked firmly around it and sleeked to conform to its original shape. All the vent from the jacket core is taken off through the four prints at the joint line.

The iron is melted in a cupola lined to 41 in. The bed charge of coke consists of 1,200 lbs., while the succeeding charges of iron and coke weigh 1,600 and 300 lbs. respectively. The charges of iron are made up in varying proportions to suit the different classes of work handled in the shop. Iron for ordinary work, such as bed-plates, frames, fly-wheels and work of a similar character which does not have to withstand a pressure test, is poured from a mixture approximating 1,000 lbs. of pig-iron and 600 lbs. of scrap. The scrap used is at all times of a superior character. Burned scrap or thin oxidised iron is never handled under any consideration.

Little outside scrap is bought and that only machinery scrap of the highest grade. The pig-iron is bought by analysis, but it is also judged by fracture. Excessive scoria on the top face or blow-holes situated under the skin is deemed sufficient cause for rejecting a casting. Several brands of pig-iron are always kept in stock, including one pile of charcoal iron. This is employed to promote density in castings subjected to a pressure test, and also to prevent segregation in castings containing sections of uneven thickness.

The steel scrap employed in making semi-steel consists principally of short pieces of rails and fish-plates. The different varieties of pig-iron and scrap are kept in individual piles, plainly marked and numbered. The charging card is made up in the office and the cupola man had no difficulty in following instructions.

The Economic Annealing of Malleable Castings.

By E. MILLER.

The enormous amount of fuel required in the process of annealing is an outstanding feature of the malleable iron industry. The fact that the weight of coal used exceeds that of the castings annealed and is in some instances twice as much, calls for serious consideration. Any system, therefore, which will reduce this consumption is of tremendous importance to the trade, especially in view of the increasing competition from Belgium and the United States.

In the past this country enjoyed an enviable position in regard to the low cost of coal, and this fact has contributed much to the advancement of the country generally, and the malleable-iron trade in particular. It has also developed a certain disregard to the question of fuel costs, with the result that at the present time we find ourselves working furnaces and other fuel-consuming plant, which are far from efficient.

The large increase in the price of coal now places this commodity in front of anything else where production costs are concerned, and in a process such as the annealing of castings, every foundryman is faced with a fuel bill which places him at a disadvantage in the face of foreign competition. If the present system of malleable annealing is analysed it will be found that with few exceptions the process has not changed since very early times. It is still common practice for the foreman or annealer to build his own furnace, usually of the direct-fired type, in which a trough of fire is placed in close contact with the pans. Further, the process is treated very much as a secret one, and the annealer often holds full sway over the output and its cost of production. While this method has given a measure of satisfaction in the past, it is now realised by most that it cannot go on; its place must be taken by some other system which will not only effect a reduction in fuel costs but also in labour.

Such a system has been in use in the works of the British Mills Foundry, Smethwick, Birmingham, for two years, and has proved so successful in saving both fuel and labour that a description of the plant and its working will no doubt be of interest to all malleable foundrymen. With this system, castings can be annealed at less than a third of the usual fuel consumption, and what is an additional advantage, the results are better and more consistent. In addition to the saving in fuel, the amount of labour is reduced to about half that usually employed.

The essential features of the system are:—(1) The use of a modern recuperative oven; and (2) continuous working secured by mechanical charging.

The oven in use at the British Mills Foundry is of the "Incandescent" recuperative type, having a capacity of 20 tons of actual castings, and was installed by the Incandescent Heat Company, Limited, Cornwall Road, Smethwick. Coke is generally used, the best results being obtained with the ordinary grades of bituminous coal, but actually the commoner grades are employed, while in some cases, when coal has been difficult to obtain, mixtures of coal and coke have given good results and the full temperature has been easily maintained.

The coal is fed into what is virtually a self-contained gas producer, situated at the back of the furnace, and the "green" gas produced is led to various ports in the side of the oven and burned there under control. Suitable gas- and air-valves are provided for this purpose. The temperature can thus be regulated and maintained with ease, and uniformity of heating to within 10 deg. C. is secured throughout the heating chamber.

The waste gases from the oven are caused to pass through the continuous recuperators, and there they give up their available heat to the incoming air required for combustion, thus effecting a considerable economy in coal consumption, and at the same time producing conditions which avoid local overheating or burning—a constant trouble with the direct-fired type of oven. An important feature of the recuperative system lies in the fact that the gas meets hot air, which facilitates the combustion and renders it more complete.

The firing arrangements are simple and do not call for an expert fireman, while the control enables a steady temperature to be maintained.

Continuous Working.

With the normal method of working, an oven cannot be run continuously; it must be allowed to cool to permit of the men entering in order to tip the pans and remove the castings and ore and finally to repack. With the newer system, the charging of the oven is done by mechanical means, and the pans are packed and emptied in the open shop. Thus the time occupied in these operations is saved so far as the oven is concerned, since it is only necessary to remove the loaded pans and replace them with newly-packed ones, a proceeding that takes only a few hours at the most. The oven does not cool more than to a dull red heat, at which temperature the pans are removed.

The machine used for this purpose is of the counterbalancing type, which consists of framework supported on two wheels and fitted with prongs or forks which are inserted under a stool or base carrying a tier of pans. The load of pans with their castings and ore is lifted by simply drawing a counterbalance weight along the top of frame, when the whole balances on the wheels which are fitted with heavy ball-bearings and thus make it comparatively easy to manœuvre the machine and its load. Without entering the oven, two men at the most can raise the pans and withdraw them from the hot oven.

The operation of unloading and recharging the 20-ton oven takes actually four to five hours, after which the doors are closed and luted up and the firing re-commenced.

Effect on Production Costs.

The high efficiency of the system is clearly shown by the following comparison between the results obtained with the old-fashioned direct-fired oven and the modern recuperative oven.

There are a large number of foundries producing ten tons of malleable castings per week, and in many cases the coal consumption is as high as 40 cwt. per ton of castings, though it might be reduced to 30 cwt. with close attention. With the system described, a five-ton output per week using a single small oven the saving amounts to 20 to 25 cwt. per ton of castings.

THE Rhodesian railways have recently awarded to a London agent representing several German railway rolling stock manufacturers a contract for 100 all-steel high-sided bogie wagons, while a larger order for railway carriage and wagon tyres required by the Egyptian State railways has also quite recently been placed in Germany.

Institution of British Foundrymen.

COVENTRY BRANCH.

At a joint meeting of the Coventry Branch of the Institution of British Foundrymen and the Coventry Engineering Society, held on November 18, Mr. F. H. Hurren (Branch-President) in the chair, a Paper on "Physical Properties of Cast Iron" was read by Mr. F. J. Cook, of Birmingham.

The CHAIRMAN said that before getting to the business of the meeting he would like, on behalf of the Coventry Foundrymen, to extend a cordial welcome to the members of the Coventry Engineering Society. In introducing the author, the speaker said that those who had heard Mr. Cook last year would be only too pleased to hear him again, and he felt sure that they would derive some amount of pleasure from his remarks on this occasion.

PHYSICAL PROPERTIES OF CAST-IRON.

MR. F. J. COOK pointed out that the foundation underlying the scientific use of cast iron in the foundry was now generally admitted to be chemical analysis. He referred to the part Professor T. Turner had played as one of the greatest pioneers in the application of science to the foundry. In castings of the larger sizes, however, other matters had to receive very careful consideration in conjunction with chemical analysis if the highest physical properties of the metal were to be obtained. The ruling factors in making successful castings were chemical analysis, body, blast pressure, hardness, casting temperature and the rate of cooling. The physical properties of two castings or two parts of the same casting cast with the same metal would vary in direct relation to the rate of cooling, even though the chemical analyses of the two finished castings were alike. The great effect on strength brought about by different rates of cooling was easily proved by either casting from the same metal bars of various sizes, or by casting bars of the same size and varying the rates of cooling by inserting in the moulds iron chills of various thicknesses.

Having given illustrations of the various effects produced by different rates of cooling, Mr. Cook said that for many years the question of the best temperature of iron at which to pour castings to ensure them having the highest physical qualities was a debatable one. As the results of many experiments it was now the universal practice that for all castings where strength and closeness of fracture were desired, the metal must be poured at as high a temperature as could be got from the cupola without the metal being actually on the boil. He referred to the experiments of Dr. Percy Longmuir and the diagrams illustrating Dr. Longmuir's researches. With regard to hardness or density, Mr. Cook said that no investigation was now considered complete that did not include tests for this property. The degree of hardness had a marked relation to the strength of the metal. He referred to the Brinell bath and cone test, the rebondimeter, the scleriscope, and drill tests, of all of which he gave a full account with illustrations. The question of blast in relation to pressure, temperature and dryness, had, in former days, received a great deal of attention in blast-furnace practice, but for a long time in cupola working it had been sadly neglected by metallurgists and foundrymen alike. From the results of many years' close attention to blast pressure and many experiments, he had become quite convinced that the pressure of the blast when melting cast iron had a great effect upon its physical properties. The lecturer gave diagrams showing the effect of variations in the blast pressure upon transverse and tensile results, and pointed out that the hardness increased directly as the blast pressure, whilst the transverse and tensile results showed an increase in strength along with hardness up to a point and then fell away again. This was characteristic of all classes of foundry irons with which he had experimented, but with a certain difference. When the iron experimented upon belonged more to the harder class, the peak of each curve became more divided. With the harder irons, the peak of the transverse curve was associated with rather lower hardness than that which gave the highest tensile results.

Dealing with the alterations in chemical composition due to variations in the blast temperature, Mr. Cook said that the results of the series of experiments of which he gave illustrations were sufficient to show the importance of attention to blast pressure; and, although the effects would vary in accordance with the type of cupola used and the class of iron melted, yet the tendency was always in the direction he had indicated. With regard to body, it was fairly well known that iron of the same ultimate composition gave widely different tensile and transverse test results, but the reason of this phenomenon had not yet been put entirely on a scientific basis. He referred at length to research upon the effect of structure upon the physical structure of cast iron conducted by Mr. Hailstone and himself, and said that one of the reasons put forth by previous workers for the phenomena observed had been the size of the graphite. Whilst not depreciating in the least the benefit in strength to be obtained from small graphite flakes, yet cases had been found where bars of higher strength had had larger graphite flakes than bars of less strength. The results of the investigations had been sufficient to show that in each case high physical properties had been associated with the net-like formation of the phosphorus, also that the graphite when in the elongated form appears to split up the phosphorus eutectic and prevent this formation. The tendency of the graphite to take either an elongated or a finely divided form was more a question of the way in which the pig-iron had been made than of its subsequent treatment in the foundry. The statement of Mr. Pilkington in this respect was very interesting, namely—"Foundrymen have always been conversant with the fact that the varying temperature at which pig-iron leaves the tapping hole of the furnace has a powerful effect on its physical characteristics. The temperature of a modern blast furnace is very much higher than formerly, and the metal takes much longer to cool than that which leaves the tapping hole of the smaller furnaces. Pig-iron from the extreme types could be made practically alike in chemical composition, but would behave physically in a different manner altogether, and would show very different grades, grains and degrees of hardness."

Discussion.

MR. E. H. BROUGHALL, opening the discussion, said that Mr. Cook, in conjunction with the late Mr. George Hailstone, was responsible for the research carried out in connection with the strength of grey iron castings, which established the theory of the network structure of grey iron. Another research which Mr. Cook carried out was in connection with blast pressure in cupolas. He trusted that the members of the Coventry Engineering Society who were present would appreciate the points brought out by Mr. Cook that evening, which gave some idea of the many difficulties with which foundrymen had to contend. In his opening remarks Mr. Cook had referred to the research carried out by Professor Turner many years ago, with regard to the effect of silicon in cast iron, but he (the speaker) was somewhat disappointed that the lecturer had not mentioned Keep's test in this connection. He considered that test to be one of the most useful a foundryman could use, because it told him practically everything he wanted to know in connection with the mixture of iron being tested. In quoting Dr. Longmuir's experiments, the author had mentioned recorded temperatures of 1,400 deg. C., but he (the speaker) somewhat doubted this, as even to-day it was almost impossible to reliably record such temperatures with a pyrometer. He would also point out that in Dr. Longmuir's investigation no mention was made of compression tests on annealed grey iron, but Dr. Hatfield had shown in his recent book the extremely bad effect that annealing

had on grey iron as regards compression. He did not at all agree that any reliability could be placed upon the Brinell method of testing grey iron. As to the drill hardness test, he had had many long discussions with Mr. Cook on this subject, and he believed that this test was probably the best test of all for ascertaining the hardness of cast iron.

MR. A. HARLEY said he was greatly interested in the author's reference to the network structure, and, personally, he thought that the theory was generally accepted. It might, however, be interesting for Mr. Cook to know that they could get two hematite pig-irons almost free from phosphorus and of identically the same composition, but in the conversion of the irons they got two totally different results after employing precisely the same process and the same converters. There was a tendency to rely very largely on analysis, but whilst analysis was extremely important and possibly sufficient when using the same brands, if they changed brands and relied on the fact that the irons had the same composition, there was a likelihood of trouble resulting. Mr. Cook had not explained why iron manufactured in the blast furnace at a high temperature was so much purer than that manufactured at a low temperature. He (the speaker) thought it might be due to the certain injurious constituents which were absorbed. With regard to the testing of metals there was no doubt that a good deal had to be done to correlate methods. In that connection he would refer to the manufacture of piston rings. Different manufacturers making these parts would get more or less similar composition and similar physical results, but they had variation in the behaviour in the engine, and that had led to a special method of testing. The job was so important that they had to test a finished ring on a specially-designed machine. Good work could be done if they got tests of a more uniform character.

THE CHAIRMAN said that he was very interested in the fact that sand was a bad conductor of heat, and in the injurious effect on the castings shown. They had had many instances of that, and he had been forced to the conclusion that where there were pockets of sand difficult of access they were very often injurious, and where possible they had induced their designers to eliminate or alter them. He was very pleased with Mr. Cook's remarks on the question of casting temperature, a matter in which he (the speaker) was very interested, and he quite agreed with those remarks. With regard to pyrometers taking such high temperatures as those mentioned in the Paper, he, like Mr. Broughall, had never found a pyrometer which would give such readings reliably. As to the relation between hardness and analysis, his firm had taken many thousands of Brinell readings on cast iron, but he must say that no reliance could be placed upon them. Two analyses of the same metal had been totally different in hardness, and he was surprised to find what a great difference there was in the Brinell readings. What they would expect to be soft was hard, and vice versa. He had never tried the drill-test method, but he hoped to do so in the future. He was pleased to hear from Mr. Cook that iron, manufactured at high temperatures, did not give such good results as that manufactured at lower temperatures. If Mr. Cook could only persuade manufacturers to realise that he would do a great deal of good. They were often supplied with pig-iron produced under anything but ideal conditions, and they were expected to make a good casting from it.

MR. F. J. COOK, in reply, said that the discussion had been a very interesting one, and had brought out a number of good points. Mr. Broughall had expressed disappointment at the exclusion of Keep's test in the Paper, but he (the speaker) thought that probably the Paper had already been long enough for one evening. Perhaps at some future time he would deal with some of the other points connected with tests for cast-iron. With regard to the high temperatures obtained by Dr. Longmuir, the experiments cited had been done at the Sheffield University, at the time the University had been going very largely into the question of pyrometers, and he had never heard them criticised before. He was surprised at Mr. Broughall's remarks with regard to the Brinell test. That speaker must have misunderstood him in that respect, since for many years he had condemned that test. Some little time ago, in fact, when he had spoken against the Brinell test in favour of the drill test, Mr. Broughall had defended the Brinell, so that it was really very pleasing to note that that gentleman had been converted. With regard to the two hematites mentioned by Mr. Harley, he thought that Mr. Harley had met with a case similar to the one he had mentioned. In the course of some experiments many years ago with two West Coast hematites he got better results with one than the other. He was considered a crank at the time, because there was nothing chemically to indicate this. When the research was finished, and he was speaking on it, one of the gentlemen in the audience asked whether they had analysed for the rarer elements, and on doing this the better iron was found to contain quite an appreciable amount of titanium. Probably Mr. Harley had got in mind the two hematites he (the author) had met with. As to the network structure, the people who objected the most about the statements made as to the effects of high furnace-temperatures were the blast-furnace people. He thought, however, that that theory had since been proved conclusively. He had commenced that evening by saying that for "light castings," casting temperature and rate of cooling were the predominant features to be watched, but that in big castings other items also had to receive attention. As to the question of getting bad results from the blast-furnace, they must remember that in one case they were producing iron from oxides and in the other they were producing castings from the iron itself. There was one point in connection with iron which had not been thoroughly investigated, and that was the question of oxides in iron. But that was a difficult matter, because they had to reduce the metal to oxide before they could get any further in the chemical investigation. He thought that when they became more enlightened on that point the question of oxides would become a very important matter. Mr. Harley had spoken of the specifications of piston rings. Whilst general specifications for cast-iron had been in a state of chaos during the war, there had been a great deal of thought put upon tests for the small parts of aeroplanes with which Mr. Harley had had a great deal to do. If they could get better methods of testing, it would be to the advantage of everybody. There was a Research Association now being formed for cast-iron, and one of the first points they would have to deal with would be, probably, the raw material used. They also had in mind the question of test specifications—consideration of which should do good.

A vote of thanks, proposed by Mr. E. H. Broughall and seconded by Mr. W. E. Cattell (secretary of the Coventry Engineering Society), was accorded to the lecturer, who suitably replied.

DISCUSSION ON REFRACTORIES IN MOULDING PRACTICE.*

MR. W. J. FLAVELL, in proposing a vote of thanks to Mr. Winterton, said there had been a good deal in the lecture which would be of great practical use to foremen and other head men in the various classes of foundries represented in that Institution.

MR. H. FIELD seconded the proposition, and said that they could not do better than take the materials Mr. Winterton had to offer them and select those that they thought would best suit their purpose. They might think that would be an experiment, but as a matter of fact Mr. Winterton had already done the experiments for them. He did not agree with Mr. Winterton as to a hefty labourer with a shovel being able to make as good facing sand as could be made in a mill. He could, however, emphasise Mr. Winterton's remarks with regard to the importance of coal-dust. Coal-dust was a refractory, not so in its natural state, but when it was burnt it left an ash which must essentially act as a refractory. He thought that fact was often overlooked by men who used coal-dust. It was too often assumed that when coal-dust was burnt there was nothing left, but they knew from experience with coal in other

See page 108.

directions that there was a good deal left, and this coming into contact with the hot metal ought to be a refractory. Not only the existence of the ash but also the nature of the ash had to be considered. Coal-dusts varied considerably in composition. He had looked into the composition of the ashes of various coal-dusts in order to discover the most suitable for his purpose. It could readily be seen that one ash was more fusible than another. The ash must form part of the sand and take its place in the sand, and therefore if not refractory would fuse and become part of the surface of the casting. With regard to graphite facings, some of these contained more mineral matter than carbon, so that in many so-called carbon or graphite blackings they had really a blacking of mineral and graphite. At the same time it must be admitted that such graphites gave good results for some work.

The BRANCH-PRESIDENT said that he agreed with Mr. Winterton as to the importance of having different classes of facings for different classes of foundry work. In the foundry in which he was engaged they made green-sand castings in a great variety of sizes, from 30 tons down to a few pounds. As they had not sufficient mills to grind all the sand they used they had to make use of the "hefty labourer," especially for their green sand. What the labourers had to do was to take the sand prepared for the heavier castings and weaken it down to suit the lighter castings. They found that to operate very well indeed. With regard to blacking, he quite agreed with Mr. Winterton in his remarks about the old-fashioned method of mixing.

They were very much indebted to Mr. Winterton for indicating something which would do its work, whether for light or heavy castings, without the addition of all these ingredients. In his foundry they had sometimes to cast at very high temperatures. It would readily be understood that in running castings of from 10 to 20 tons from an air furnace the temperature of the metal could not always be definitely regulated, and consequently the behaviour of the refractory was a matter of great importance.

MR. H. L. REASON remarked that they all realised how much the character of the castings depended upon the material used in preparing the mould. They had to consider getting a good surface and at the same time a solid casting. If they did not get a good surface the casting was an eye-sore, and if the skin was not suitable they experienced considerable difficulty in the machine shop. The producing of successful castings of different weights required something more than rule-of-thumb methods if the best results were to be obtained. For instance, Mr. Winterton had called their attention to the importance of the coal-dust being graded in accordance with the work it had to do. He had not had the varied experience of Mr. Winterton, and could not presume to make any suggestion to him. But he thought they would agree that for small or medium-sized foundries it was a question not of selecting the correct material but of taking what came along.

The subject of refractories and special sands was somewhat outside the ordinary province of an ironfounder. The larger foundries, where they had chemists and special facilities for dealing with these matters, had advantages which the smaller foundries lacked, and it was satisfactory to know that they had someone to whom they could go if they wanted information in that direction. As to the work turned out by the old-time foundries, it should be remembered that the foundrymen of that period had not to turn out castings at anything like the competitive prices now prevailing. If a man got a waster he made a fresh casting, and if that failed he made another. When he got a good one, he did not know why, and he just continued the same operation until something again went wrong, and then he would try some other way. Nowadays they had not time to do that sort of thing. Taking into consideration the difficulties under which their predecessors worked, he was quite prepared to give them all the credit they deserved, but he could not admit that they made better castings than were made to-day. He contended that better castings were now being made than were ever made before. To-day foundry managers knew exactly how to grade the iron they were using and also the composition of all that went to make the finished casting. Further, as the lecturer had pointed out, they knew what could be done by scientific treatment of their metal and their moulding materials. He would like Mr. Winterton to give them a rough idea with regard to the best mixtures for facings and to give them the benefit of some of the valuable knowledge and experience he had of the various sands which were to be found up and down the country.

MR. FLAVELL, referring to Mr. Reason's remarks about old-time foundries, said that there must have been some splendid workmen in those days, and even if they had more time for their work great credit was due to them. He asked Mr. Winterton whether he had had any experience as to dressing or facing for permanent moulds. This was a matter upon which information was desirable, as it affected a very big trade in the Black Country—the making of chilled roll castings. The old-fashioned method of preparing chills was merely to clean, clay-wash (with a mixture of clay-wash and ashes) and black them. They used to consider that if a roll was cast badly it was owing to the defects in the dressing.

MR. J. MATTHEWS raised the question as to whether it was correct to speak of coal-dust as a refractory material. This was not true when it was in the form of powder. When the gas was given off, through the molten metal coming in contact with it, the gas certainly did act as a refractory. This film of gas prevented the metal cutting into the sand facing, resulting in a clean casting being produced. If too much coal dust, however, was put into the facing, the large quantity of gas generated lodged in the corners and all the sharpness of the casting was lost. He had often seen this in the case of malleable castings.

MR. REASON said that they had a similar discussion a year or two ago, and they were then told that the moment the molten metal came into contact with the mould the coal-dust gave off gas and just in the transition of the metal from molten to solid there was a volume of gas between the casting and the mould which assisted the formation of a good surface on the casting. He did not think Mr. Field was quite right in suggesting that coal-ash formed a refractory for this purpose. The percentage of ash was too low to be of use in securing a good skin.

MR. FIELD replied that what he intended to say was not that coal-ash was a refractory, but that it was essential the ash should be of a refractory character.

MR. REASON: It does not form a refractory.

MR. FIELD: No, but with the various qualities of coal-dust, the ash in one case may be more refractory than in another. If that is the case, the ash in some cases will fuse. Coal-dust is not used with the idea of its being a refractory or even as a flux, which term implies something that will flow or melt. This is undesirable to have in contact with the casting. When the coal-dust has been burnt something is left which must be of a refractory character or it would fuse on the surface of the casting. If 1 per cent. of lime in a moulding sand is detrimental, surely the grains of coal-dust ash, which may contain 5 to 10 per cent. of lime, should also be deleterious.

MR. H. PEMBERTON said that there was one point which had not yet been raised, that was the use of the different blackings in blacking a mould. There were graphite, mineral, and charcoal blackings. It would be rather interesting to know the functions of these different blackings.

MR. WINTERTON, replying, said that those who remembered his previous lecture would gather that he was going to be somewhat biassed in his reply. One member had advanced a theory which he himself advanced in his previous lecture and which led, not only there but also in other parts of the country, to considerable discussion. The question was, "What are the functions of coal-dust?" He maintained that they were twofold. One function was to assist in the venting of the mould by forming a lead-off for the gases to escape, and the other was to form on the face of the mould a gas which should act as a buffer to the metal. He would suggest that if it were not so, one might

always use very fine coal-dust for even the biggest castings, and that the size of the particles was immaterial so long as coal-dust was present. They used a coarser coal-dust for the heavier mould because then the particles when fused would leave wider spaces for the air to get away from the top of the mould. He did not quite agree with Mr. Field's remark about the labourer and the power machine for mixing sand. The usual centrifugal machine, although it sieved and mixed fairly well, frequently left the sand and other material in layers, so that after all they had to get a man to mix it. The remarks made by Mr. Field with regard to coal-dust bore out the theory he (Mr. Winterton) mentioned in his previous paper, namely, that coal-dust was not used in the mould primarily as a refractory, although when the coal burnt an ash which was a refractory was produced. As to the question why coal-dust was put on the metal, it was simply put on to keep the metal hot, but for that purpose he would certainly recommend, instead of coal-dust, some common refractory.

MR. REASON: In the non-ferrous foundries covering the metal with charcoal has a considerable effect in that way. In fact, it is practically impossible to make sound non-ferrous castings without keeping the metal covered with coal-dust or charcoal.

MR. WINTERTON, replying to Mr. Pemberton's question, said that charcoal was used on light castings. How it acted could be seen most effectively on hollow-ware castings, where it was simply dusted on and then blown off, so that only quite a small proportion remained on the mould, being just sufficient to form a skin. When they got to a heavier weight of metal, charcoal, of course, would be too light; it would burn too quickly, and, in fact, would fuse immediately. Therefore for heavier castings they must have something of a more refractory character. Graphite was one of the highest refractories used in the foundry. If it were possible to use plumbago in every foundry that would be by far the best plan. But plumbago was very expensive, and there were now on the market certain refractories which, whilst they would not give such good results as plumbago, would certainly do the work most effectively.

The Layout of the Pattern Shop.

BY JAMES EDGAR.

The pattern shop should always be adjacent to the foundries. Many old-established works would find it an ultimate economy to rearrange the shops or build a new pattern shop close to the foundry, because the time that is lost by pattern makers and moulders or labourers in going between these shops is considerable, and mistakes are caused through the moulders' judgment being at fault, which does not occur when a consultation can conveniently take place. The proximity of the drawing office is not as important, because usually only the foreman pattern maker goes there, and the draughtsmen are almost as frequently in the other shops as in the pattern shop.

Because of the pattern shop being a woodworking shop, an upper flat is often considered by the works management as quite satisfactory. It may answer the purpose if only a small class of work is done, but even then it is not always profitable. Men cannot give of their best if the floor is all the time vibrating because of planing machines and circular saws, or a line of shafting underneath. This applies also to the two-flat pattern shop. It is quite common for a pattern shop to have a balcony without machines, and the men have consequently to go downstairs reneatedly to get timber. This is a deplorable waste of time and energy. It will invariably be found by comparison that work executed downstairs is cheaper than that done upstairs for this reason. Furthermore, the ventilation of a balcony is seldom satisfactory.

The floor is an important factor in pattern production. Earth floors are not common now, but they were until a few years ago, and they were both insanitary and inconvenient. Many pattern shops have a concrete floor, which has the virtue of being clean, and as footboards are invariably used, it is comfortable. There is the disadvantage, of course, with a concrete floor that nails cannot be driven into it, and in shops where medium-sized and large work is done, this is often wanted. It is imperative that every few feet there should be a wood joist, so that level skids can be laid down in any part of the shop for building purposes. The best floor is undoubtedly one formed of wood blocks, but it is also the most expensive. It is very important also to have a special level floor in the pattern shop. This should preferably be raised a foot or two from the floor. It should be solidly built, and its area must depend on the class of work carried out. From time to time such level floors have to be re-planed to ensure their being "true." The level floor should never be used for purposes that can be quite well carried out elsewhere.

There has always been much controversy as to the need for a surface table in the pattern shop. Such a table is never indispensable, but often useful, but it should be for the use of all the pattern makers in the shop, and not merely for the convenience of the foreman in checking work. It is not quite fair that work should be subjected by the foreman to the severe test of a surface table, if the craftsman has not had the opportunity of using it while making the pattern. The best kind of table, in the writer's opinion, is a heavy wooden table, carefully kept in good condition, and with one or two squared faces. On such a table every kind of dividing can be done, and centres marked and tested far more easily and quickly than at the bench.

Perhaps the most important thing in laying out a pattern shop is settling the position of the benches in relation to the machines. Some firms prefer to have the machines in a separate shop, and the advantage of this is that the atmosphere of the bench shop is better because there is no dust, but there is the very big drawback of inconvenience. It is not wise to place benches close to machines and there should be in large shops a wide passage down the centre of the shop with machines on one side and benches on the other. This is a better arrangement than crowding the machines together at the end of a long shop. The only machines to which this should not apply are the trimmers. There cannot be too many of these handy machines in a pattern shop, and it is a far-sighted policy to place a small one at the end of each bench.

In determining the positions of the machines in relation to each other, much depends on the class of work that is done. If only very small patterns are made the machines may be close together, but otherwise there should be a distance between. It is obviously foolish to place a planing machine so close to a bandsaw that only short timber can be planed and sawn, and yet this is often done. Also some regard should be given to the order in which the machines are most commonly used. Apart from occasional cuts, pattern makers, in breaking out timber, usually go to the circular saw first, then to the surface planing-machine. The thicknessing planing-machine—when there are two planers—is next in order, after which the bandsaw work is done. The sandpapering machine is usually the last machine to be used.

Almost as important as machining is the method of driving it. There is much to be said for a line of shafting and belt drives, but much can also be said against it. The direct drive has peculiar advantages in its favour for pattern shop work. It is very seldom even in large shops that all the machines are in use at one time, and frequently only one or two are in use, and there is thus a big loss of power. When each machine has its own motor, there is no power loss. There is another thing to be said for the direct drive that a broken belt does not hold up all the machines. Another way of reducing power cost is, instead of adopting direct drive, to have roller bearings instead of ordinary bearings for the shafting. There is also a greater scope in locating the positions of the machines when the direct drive is used.

It is not possible to say definitely, without regard to conditions, what is the best position for the lathes, of which there ought to be at least two. If possible, they should be well clear of the other machines to guard against accidents.

Benches in pattern shops are invariably far too long. Either for small or large work short benches are quite satisfactory, and the additional floor room obtained from using them is always useful. Even if large boards have to be planed, a support can be used. It is rather surprising that even to-day the antiquated wedge is not unknown, and the wooden "lug" is more often the rule than the exception. One of the best labour-saving devices in a pattern shop is an iron quick-action vice. There are several good makes on the market, and they very soon repay their first cost. The vice is one of the several little things in the pattern shop which is thought too insignificant to study, but which nevertheless has a very big influence on costs.

Dust extracting plant has been quite common in joiners' shops for many years, but only recently have firms thought it worth while to instal such a system in the pattern shop. Yet it is necessary, and it can confidently be predicted that in a few years almost all pattern shops will have some system of drawing off dust. The common use of sandpapering machines has made it more necessary than ever.

XUM

Trade Talk.

Woolwich Arsenal and dockyard workers have been advised by their unions to accept the Government short time scheme for the present.

The Executive of the National Union of Railwaymen have voted a grant of £1,000 to the Austrian railway workers, who are passing through a severe famine.

IN consequence of the depresed condition of trade it has been found necessary to give a week's notice to the blast-furnacemen employed at the Spring Vale Furnaces of Alfred Hickman, Limited

AN interesting lecture on "Gear Tooth Forms" was given recently by Mr. E. W. Tipple, of Leeds, before the members of the Sheffield Branch of the Association of Engineering and Shipbuilding Draughtsmen. Mr. T. Cusworth presided.

THE VULCAN FOUNDRY, LIMITED, of Newton-le-Willows, Lancashire, have contracts for seventeen metre gauge 4-6-0 type locomotives for the Assam Bengal Railway, and also for ten 4-6-0 type locomotives for the Great Central Railway.

To Messrs. Robert Stephenson & Company, Limited, Darlington, has been awarded a contract for an additional ten 4-6-0 type locomotives for the Bengal-Nagpor Railway, and for three "Port" class engines for the Sudan Government Railways.

In pursuance of their decision to restrict the output of ships on account of the high cost of production, the Lloyd's Royal Belge (Great Britain), Limited, have decided to suspend operations in their shipyard at Glasgow, and already 800 workers have been paid off.

The Electricity Commissioners, who were approached in connection with the Ministry of Transport under the Electricity Act, 1919, have decided to hold a local inquiry with reference to the London and Home Counties electricity district, and any schemes relating to it. The inquiry will begin in June.

WITH a view to investigating the causes of the present industrial depression in the iron, steel, and allied industries a conference has been held in London between the National Employers' Federation and the Iron and Steel Trades' Confederation. A committee, representative of both employers and workpeople, has been appointed.

In view of the present position of the iron and steel industry, the establishment of the Springvale Foundry Company, Limited, in Victoria, Australia, has its significance. The foundry will chiefly manufacture castings and will specialise in repetition work. In addition, the general requirements of the machinery trade will be considered.

Recently, Mr. Frederick L. Blow addressed the members of the Cardiff Technical College Economics Society upon "The Lighter Side of a Serious Business." The lecturer dealt with his subject in an interesting manner, and the many incidents of humour and pathos drawn from his twenty years' experience as a stockbroker were much appreciated.

Mr. John Hill, general secretary of the Boilermakers' Society, speaking at Newcastle on the recent conference between shipbuilding employers and their workmen, said it had been reported that the workers' delegates were going to drop the demand for an advance of wages, but they were not. They were also going to ask for an inquiry into profits.

Before the members of the Middlesbrough High School Engineering Society a very interesting paper, "The Making and Testing of Iron and Steel," was read by Mr. D. Sillars, chief chemist, Bolckow, Vaughan & Company, Limited. The author dealt exhaustively with the most modern methods of iron and steel manufacture, illustrated by lantern views.

The Queensland Government, according to mail news, proposes to proceed with its State iron and steel works project, and has decided to exercise the option it holds over the purchase of the mineral rights of Cockatoo Island, Yampi Sound, Western Australia. It has been declared that the manufacture of steel from ore as rich as that of Yampi would be extremely easy.

The oil tanker steamer "San Felix," 530 ft. long, and designed to carry 18,500 tons deadweight, was launched on the 24th ult. from the Walker yard of Messrs. Sir W. G. Armstrong, Whitworth & Company, Limited, the christening ceremony being performed by Mrs. Riba, wife of Mr. Louis Riba, vice-president of the Mexican Oil Company, Limited, in the presence of a large company.

Speaking on unemployment at a recent meeting of the National Unionist Association, Dr. Macnamara said that in consequence of the adoption of short time the Admiralty would be able to bring into the Royal Dockyards between four and five thousand men now unemployed. A system similar in principle was being worked by the War Office. A thousand men had already been brought back

SIR W. G. ARMSTRONG, WHITWORTH & COMPANY, LIMITED, of Scotswood, have secured the order for five 4-4-0 type locomotives for the Midland Great Western Railway, Ireland; and Messrs. Kitson & Company, Limited, of the Airedale Foundry, Leeds, have been allotted the contract for twenty boilers required for heavy 2-8-0 type locomotives for the Great Central Railway Company.

EFFORTS to secure a reduction in the wages of the stampers at the works of Messrs. Vaughan Bros., Willenhall, were considered by the members of the Blacksmiths' and Ironworkers' Society. The local secretary pointed out that negotiations were at present taking place to arrive at a general settlement of the whole matter for the trade, and said if a drop had to come it should be uniform.

THE first meeting of the temporary executive of the National Union of Blast-furnacemen, Ore Miners, Coke-workers, and Kindred Trades was held at Middlesbrough last week, when the following officials were nominated:—President, Councillor H. Nixon, J.P. (secretary of the Eastern Midland District): secretary, Councillor Thomas McKenna (secretary of the Cleveland and Durham District).

Despite the fact that the latest official figures show the rate of unemployment to be increasing throughout the country, it is of interest to note that the mean percentage of the unemployed for the past year was below that recorded for any of the years from 1900 to 1912. At 2.4 per cent. it equalled the 1919 figure, was very slightly above that for 1913 (2.1), and was actually under the return for 1914 (3.3).

The mercantile shipbuilding statistics of the world for the past year, issued by Lloyd's Register of Shipping, shows that during 1920 there had been launched in the United Kingdom:—556 steamers of 1,953,014 tons, 25 motor vessels of 86,940 tons, 37 sailing vessels and barges of 15,670 tons. The output for 1920 was the highest ever reached; it exceeded the previous year's total by 435,182—over 26 per cent., being 142,371 tons higher than the previous record figures of 1913.

Speaking on the subject of "Industrial Harmony," at a gathering at West Hartlepool in connection with the Central Marine Works of Messrs. Wm Gray & Company, Sir George Gibb remarked that a great deal had been heard recently about labour having a voice in questions of management, and said he believed it would be a strength, and not a weakness, if the voice of every interest concerned in industry had the means of expression.

A notable docking feat on the Tyne was accomplished recently, when the large Italian liner, "Guilio Caesare," 633½ ft. in length, was safely docked in Palmer's large graving dock, Hebburn, for painting and examination prior to completion. The vessel is designed to reach a speed of over 19 knots, and is also the biggest ship placed in the Hebburn dock, the largest on the North-East Coast, being about 28 ft longer than the Red Star liner "Lapland," which has been in the dock on two occasions.

THE BRITISH CAST IRON RESEARCH ASSOCIATION, jointly with the Institution of British Foundrymen (Birmingham Branch) will hold a meeting to-day (Thursday), February 3, 1921, at the University, Edmund Street, Birmingham, at 7.30 p.m., when a lecture will be given by Mr. J. G. Pearce, B.Sc. (Manchester), upon "The Value of Scientific Research to Iron Founding." The chair will be taken by Prof. T. Turner, M.Sc. Foundry proprietors, and all interested in cast-iron production, are invited to attend.

Sir Leonard Llewellyn, in his presidential address to the Newport Chamber of Commerce, said that when the man in the street was told that they had in South Wales sufficient coal to last for the next 600 years he believed it, and was contented. He ventured to suggest that it would give him a shock, or at any rate food for thought, to know that the large majority of the best seams in South Wales had been worked out, and that at the end of 60 years the output of coal in South Wales would be such that our industries will be dependent not on coal, but some other form of motive power.

THE engineering and shipbuilding unions met the Federation of Shipbuilding Employers on January 21 to consider the wages question. At the conclusion of the conference Sir Charles Saunders stated that the employers had intimated that the claim for a general advance of 6d. an hour must be refused. "The whole position was gone into in a perfectly friendly way," said Sir Charles. "The shipbuilding employers decided that they could not see their way to agree, as the engineering employers have done, to stabilise wages for six months or to postpone the claim for that period. The negotiations on the general wages question are now concluded."

IRON AND STEEL MARKETS.

Pig-Iron.

Although movements in the pig-iron trade during the week have given but little encouragement to the optimistic section, evidence is not altogether wanting that some measure of hope is entertained of a return to more active conditions as the year progresses. That this view is entertained by some makers is confirmed by the restarting last week of two furnaces at Acklam Ironworks at a time when steel manufacturers have made big cuts in prices to meet foreign competition. These works are part of the plant of the North-Eastern Steel Company, associated with Dorman, Long & Company, and three hundred more workers will find employment. In the meantime, the downward trend of prices of pig-iron continues, latest reports from Scotland indicating a movement in that direction in the Glasgow market, where values are expected to be immediately reduced, as it is becoming more and more difficult to secure buying on any scale of magnitude at current quotations. In South Staffordshire also conditions are adverse to active buying, and although it is admitted that smelters' concessions already quite cover the advantages of cheaper fuel recently secured, consumers are exercising continuous pressure for still further reductions. On the other hand, makers contend that other costs of production as well as fuel must be considered, and it is even stated that some furnace interests are prepared to suspend operations rather than continue business at a loss. In Lancashire transactions in the foundry iron market continue on a restricted scale, and although it is stated that consumers have still a fair number of orders in hand, and are working on stocks accumulated or ordered some time ago, many of the foundries placed heavy contracts at a period when values were greatly inflated, and are now endeavouring to induce suppliers to modify the terms in accordance with recent reductions in prices. At the time these orders were placed, however, Midland smelters were in a better position, perhaps, to name their own terms, but these conditions no longer prevail when measured on the basis prices of Cleveland pig, which, if it can be bought by Lancashire consumers, show a by no means unimportant advantage to buyers. Some attention is being paid in the Manchester market to reports that Belgian pig-iron is now on offer as low as £6 per ton, c.i.f., at British ports, which would mean round about £7 delivered locally. There is as yet no authoritative confirmation of the report, but it is none the less evident that Belgium is in active preparation for a descent in force in our home markets. Business in the Cleveland iron market of late, both for home and export, has been distinctly slow, buyers except for immediate necessities acting with reserve, and mostly avoiding anything as concerns forward transactions. Nor has this attitude of consumers been greatly affected by the recent price concessions of makers, which are, so far, regarded as quite inadequate to the circumstances of trade in general. Considered in its relation to the export question, the decision of the Cleveland Ironmasters' Committee last week, while leaving the position in the home trade undisturbed, to revise the prices for export business, has had no effect upon inquiries from abroad, as demonstrated by the returns of pig-iron shipments for the first month of the year, which are much below the tonnage for the corresponding period last year, and represent a heavy fall in the total then recorded. Home quotations for Cleveland pig-iron now rule as follows :—No. 1 and silicious, 225s.; No. 3 G.M.B., 215s.; No. 4 foundry, 214s.; No. 4 forge and mottled, 212s. 6d.; white, 210s.; the premium for export in each case being 5s. per ton.

In the East Coast hematite trade the continued inactivity of the steel industry has had an adverse effect upon demand, and business all round is extremely quiet, if not actually idle. The recent reduction of values for hematite has evidently been without effect as a stimulus to export buyers, and transactions on either prompt or forward account are on a very limited scale. The price remains unchanged at 240s., both for home and export.

At Barrow the position of the hematite pig-iron trade of North Lancashire and South Cumberland remains very much the same. The depression is being keenly felt and the outlook for the immediate future, at all events, is very gloomy. The production of iron has been cut down to very small proportions, and there does not appear to be much prospect of a revival until the high cost of production has been largely reduced. The acceptance by the Furness miners of a reduction of 3s. 1d. per day in their wages last week marks the first step in the desired direction, but miners and iron workers in other parts of the North West area are not inclined to follow their example. As previously reported, there was a cut last week in iron prices, and now mixed numbers of Bessemer iron are at £12 per ton net f.o.t., with special brands at £13 15s. and up per ton net f.o.t.

Ore.

No revival can be reported in the foreign ore trade at Middlesbrough, as consumers have heavy stocks and deliveries are on an increased scale. Over 200,000 tons has come into the Tees this month, and with boats plentiful the freight is slumping. As low as 10s. has been paid from Bilbao to the Tees, but 9s. is now named as the freight, on which basis the c.i.f. figure for best rubio ore is 40s. per ton. At Tyne Dock last week the imports were as follows :—The "Tressillian," from Benisaf, 5,585 tons; the "Kostrena," from Port Briera, 4,059 tons; the "Magdalena," from Algiers, 3,250 tons; and the "Rolf," from Bilbao, 1,800 tons for the Consett Iron Company, Limited; the "Capac" and "Tynedale," both from Port Briera, 4,100 and 4,260 tons respectively for Palmers Shipbuilding & Iron Company, Limited. In West Cumberland more native ore mines were closed down last week, and many of those that are working are mining only half their normal output. The importations of foreign ore were heavy last week.

Scrap.

Conditions throughout the scrap trade continue idle, industrial slackness everywhere having reduced demands for this material to almost a negligible quantity. In the Sheffield market there is quite a glut of supplies with practically no buyers, while prices have receded to almost nominal values, only about half the amount being quoted for heavy steel in comparison with the figures ruling about a twelvemonth ago. In South Wales the scrap market is lower all round, and it is difficult to find buyers for some classes of material. Prices are more or less nominal at: Heavy steel scrap, £5 10s.; heavy steel turnings, £5 to £5 10s.; steel scrap and shearings, £5 10s.; mixed wrought iron and steel scrap, suitable for basic furnaces, £2 to £5; heavy cast-iron scrap in big pieces, £6 10s.; and good machinery scrap for foundry use, £10. A similar state of business may be noted on the North-East Coast, while in Lancashire there is now practically nothing doing in the market for scrap, buyers having withdrawn altogether for the time being. Dealers quote £10 for the best kinds of cast-iron scrap, wrought scrap is quoted at about £8 per ton delivered, and heavy steel scrap at about £5 10s. per ton. In Scotland demand for scrap continuous slow, the following representing about current values :—Steel turnings £6, borings £5 7s. 6d. to £5 10s, heavy piling malleable scrap £7 to £8, best machinery £11, and heavy cast (ordinary quality) £10.

Steel.

Depression in some departments of the steel trade at Sheffield is growing more acute, the prevailing slackness more especially affecting the markets for raw and partly manufactured materials, while the branches catering for the shipbuilding industry are also experiencing a shortage of fresh orders. In this connection it may be noted as significant of the slump in marine construction that of the 8,000 registered as unemployed in Sheffield, nearly 3,000 of the total are in the engineering branches, rendered idle as a result of the falling off of work in the shipyards and motor manufacturing works in the district. On the other hand, there are reported certain branches of Sheffield trade where sufficient skilled labour is not available; they are the highly-skilled engineering sections and the wagon-building and repairing industry. Makers are also busy on the construction of forges, presses and mills for steel works overseas, and this branch requires such a degree of practice and training that an adequate number of workers cannot be secured. It is satisfactory to note also some revival of activity in demand for most descriptions of industrial hand tools, many merchants being desirous of replenishing depleted stocks. A considerable number of open-hearth furnaces in the Sheffield district are still idle, not having been restarted after the holidays, while those remaining in operation are mostly working short time. There is, however, more activity observable in the heavy engineering branches, but the disorganised financial conditions now prevailing in the world's commercial centres precludes the early placing of further orders for much needed material. In the ferro-alloys section buyers are still maintaining a cautious attitude, and price-cutting has become the general rule, the decreased demand for high-speed steel perhaps explaining the position of this class of raw material, of which an outstanding feature is marked in the decline in ferro-

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tungsten, reported to have been sold recently at as low a figure as considerably below 2s. per lb. Further weakness has also developed in the market for semi-products, where foreign competition is most acute. The Continental prices for basic billets continue to decline, and large quantities of the material are said to have been bought, but so far the first-grade qualities have been immune from foreign competition, leaving the margin between the home quotations of acid and basic billets wider than has been previously experienced. At Birmingham recently Staffordshire hoops were reduced by a further £3 15s., making the basis £23, Lancashire makers also reducing their price to £23 5s. for soft, best remaining unchanged. Steel bars are very weak. Steel sections are now established on the lower basis already announced, namely, angles and joists £21, tees £22. The fall in ship, bridge, and tank plates amounted to £2, the price now being £22 10s. In South Wales, although official quotations of steel bars are maintained at £17 10s., makers have agreed to accept £16 in order to meet foreign competition, but the concession has produced little effect, and the market remains depressed.

Finished Iron.

A survey of the present position in the finished iron trade reveals little encouragement for the immediate future, the limited volume of current inquiry, combined with steadily increasing foreign competition, affording substantial grounds for apprehension on the part of makers whose order books are approaching depletion, while others, more fortunately situated, may well be excused for some anxiety in this connection. Many works in the various districts are already working a good deal under capacity output, and orders in course of completion are only for prompt requirements, very few makers now attempting to manufacture for stock purposes, which would involve a considerable strain on capital resources difficult to maintain in these times of restricted credits. The trend of prices in the bar trade continues steadily in a downward direction, the most recent movement having been the decision of Staffordshire and Yorkshire makers to reduce quotations to a basis of £26 10s, the North-East and Scotland £25, and Lancashire to £24, the latter, it is reported, being anxious to set values at even a lower level. For example, Lancashire crown bars for export have dropped from £27 10s. to £22 to £24, f.o.b., and iron hoops from £28 to £26. Marked bars remain, so far, unchanged at £31 10s., but only a quiet trade is now doing in this class of material. Further price adjustments may be anticipated in the near future, in an attempt to stimulate demand for finished material, of which enormous quantities must eventually be required to renew the stocks depleted during the war period, and to meet the needs for constructional purposes at home and abroad. The imports of iron, steel, etc., at Hull from abroad in the week were :—Iron.—Pig, 292 tons (Bleasdale & Company); billets, 50 tons (Wilson's and N.E.R. Company); bar, 150 tons (Furley & Co.), 123 tons (Wilson's and N.E.R. Company); scrap, 110 tons (Hull Forge Company), 28 tons (Ellerman's Wilson Line) Steel.—52 tons (W. H. Bowater), 56 tons (Bleasdale & Company), 101 tons (Furley & Company), 17 tons (Huil & Netherlands S.S. Co.), 52 tons (Ellerman's Wilson Line), 345 tons (Wilson's and N.E.R. Company). Goole.—Iron, 6,285 bars; steel, 7,870 billets; 855 plates; 95 girders, 174 bars, and 74 bundles ditto. Grimsby.—Quantity of pig iron and 576 steel castings.

Refractories.

The general position of the refractories market shows no great change, though the demand for crucible ganister and crucible making clays by the Sheffield crucible steel makers shows a little improvement.

The demand for steel foundry sand has improved and is now resuming a more normal position, though many of the foundries are working from accumulated stocks.

The demand for magnesite bricks is still maintained, but the demand for dolomite for basic furnaces has fallen considerably.

Silica bricks are in fair request, but most makers are holding good stocks, and prompt deliveries can be given.

Prices of refractory materials remain firm, and manufacturers have not been able to reduce by any appreciable amount, as the rate of wages controlling prices is still the same.

The following are approximate net prices of the principal refractories :—

Best Silica Bricks (special quality).—£19 per 1,000, delivered U.K.

Ordinary Quality Silica Bricks.—£15 10s. 6d. per 1,000, free on rail makers' works.

Firebricks (best Scotch).—£12 15s. per 1,000, free on rail makers' works.

Firebricks (best Sheffield quality).—£11 per 1,000, free on rail Sheffield.

Firebricks (common). — About £10 per 1,000, delivered U.K.

Magnesite Bricks.—£137 10s. per 1,000, delivered U.K.

The above are for 2½-in. bricks, the 3-in. sizes being one-fifth more as a rule.

Dolomite (basic).—78s. per ton, free on rail makers' works.

Magnesite (dead burnt).—Peas and powder, £26 per ton (in bags), delivered U.K.

Steel Moulders' Composition.—Moulding sand and silica sands are quoted delivered, but the prices vary too much in different districts for inclusion here.

Fireclay (ground) varies with quality, 30s. to 40s. per ton, free on rail makers' works.

Ganister.—Cupolas, ladles, converters and similar purposes from 30s. to 32s. 6d. per ton, free on rail makers' works, according to quality.

Tinplates.

Although ostensibly there has been no change in the general conditions of the tinplate trade, a more optimistic tone is observable in markets, and with prices firmer on the whole and some improvement in inquiries on Continental and Eastern account, the outlook is regarded as slightly more promising. For the moment, however, actual business continues quiet, and a majority of works are idle, the number of mill-hands now unemployed being estimated at about 5,000. One of the most encouraging features of the position at present is a revival of a more active demand for wasters, of which China has been a substantial buyer of late, the price stated being about 23s. f.o.t., while some odd sizes have sold on home account. The recent heavy fall in freights also enters as a favourable factor in the export trade, opening up the probability of Spain coming into the market for plates. Current quotations are :—Cokes, 20 × 14, 33s., 36s.; quarters, 36s., 38s.; cokes, 20 × 10, 47s., 49s.; ditto, 28 × 20, 66s., 72s.; ternes, 28 × 20, 70s., 72s.

Metals.

Copper.—The market for this metal last week suggested increased activity, mainly, however, on speculative account, but values ruled lower owing to the improvement in the American exchange. Opening this week with an easier tendency, manufacturers, though still holding reduced stocks, reserved buying orders pending some improvement in export trade for finished products. A better inquiry, however, developed later, and the close was steady. Refined copper was dull and easier, and both electrolytic and wire bars finished on lower levels. Closing prices :—Cash : Wednesday, £68 2s. 6d.; Thursday, £69 10s.; Friday, £67 15s.; Monday, £67 15s.; Tuesday, £69 12s. 6d. Three Months : Wednesday, £68 10s.; Thursday, £70 2s.6d.; Friday, £68 15s.; Monday, £68 5s.; Tuesday, £70.

Tin.—Eastern cables reported no business doing. The week's tin markets on this side opened a shade easier for forward account, and with somewhat free selling orders, values receded about 40s. for this position. Subsequently better buying developed for three months, and with an improved demand for cash metal there was an all-round recovery. Consumptive demand is, however, still inactive, owing to the slump in the tinplate industry, and the falling off in American demand, but the market closed steady with a fairly good turnover reported. Straits was quoted £187, Australian £178, Banca £193 10s., Chinese £161 10s. to £162 10s., bars £165, refined £168 10s. to £169. American spot 30.00 c. (£173 15s.). Closing prices :—Cash : Wednesday, £169 10s.; Thursday, £174 10s.; Friday, £167 10s.; Monday, £168 10s.; Tuesday, £168 10s. Three Months : Wednesday, £175; Thursday, £180 10s.; Friday, £173; Monday, £174 10s.; Tuesday, £173 15s.

Spelter.—Business in this metal has continued quiet on the whole, but with few sellers in the market values appreciated both on prompt and forward account, closing with ordinary prompt quoted £24 10s., February £25, March £25 7s. 6d., April sold at £25 10s. to £25 15s., and May £25 15s. English was nominal at £26 15s.; electro, 99.9, nominal, £34 10s. to £35; zinc dust, 92-94, nominal, £60; and zinc ashes, 70 per cent., nominal, £6 10s.

Lead.—With an improved demand for the electrical trade, the lead market showed a more active tendency, but closed slightly irregular with soft foreign prompt quoted £23, February sellers £23 10s., buyers, £23 5s., March £23 12s. 6d., April £23 15s., and May £23 17s. 6d. English was unchanged at £25.

SIEMENS' STEEL PROCESS

BOILER, SHIP and BRIDGE PLATES, etc. ANGLES and all forms of Sectional Bars. TYRES and AXLES to all requirements. CASTINGS of all kinds and of Largest Sizes. FORGINGS of every description. BILLETS, BLOOMS, RAILS.

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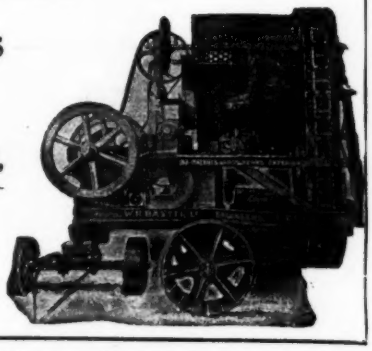

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Company News.

Consett Spanish Ore Company, Limited. — Interim dividend of 2s. per share.

Consett Iron Company, Limited.—Interim dividend of 10d. per share on ordinary and 8 per cent. per annum on preference.

Underfeed Stoker, Limited.—Interim dividend at the rate of 1 per cent., free of tax, for year ending December 31, 1919.

Antrim Iron Ore Company, Limited.—Dividend for last six months of 2s. per share, less tax, and a bonus of 2s. per share, free of tax.

Staveley Coal & Iron Company, Limited.—Interim, 9d. per share on fully-paid and 6¾d. per share on part-paid shares, being 7½ per cent. per annum, tax free.

Gloucester Railway Carriage & Wagon Company, Limited.—An interim dividend for the half-year ended November 30 at the rate of 10 per cent. per annum, less tax, is declared.

Canada Iron Foundries Company, Limited. — Net profits for the year ended September 30 were $652,947, and $166,356 was brought forward. A dividend of 4 per cent. is proposed on the preference shares, adding $50,000 to the reserve and $195,059 to the depreciation fund, and carrying forward $144,855.

Charles Tresider, Limited. — Capital £5,000 in £1 shares. To carry on the business of general and foreign importers, manufacturers of machine and engineers' tools and scientific and mechanical apparatus, mechanical and electrical engineers, metallurgists, etc. Registered office: 160, Corporation Street, Birmingham.

Wagon Finance Corporation, Limited.—The report of the directors for the year ending December last shows, including the balance brought forward, a profit of £18,092. The directors recommend a further dividend of 7½ per cent., less tax, making 12½ per cent. for the year; transfer to reserve (making it £25,000), £3,000; and carry forward, £6,029.

Harrison & Gray, Limited.—Capital £5,000 in £1 shares, to take over the business of brass and malleable ironfounders carried on by J. Harrison and C. Gray at Falcon Foundry, Walsall, as "Harrison & Gray." Registered office: Falcon Foundry, 313, Green Lane, Walsall.

Lancashire Colliery & Mill Furnishing Company, Limited.—Capital £100,000 in £1 shares. Registered office: York Chambers, Wallgate, Wigan.

J. Tylor & Sons, Limited.—Directors announce they are not in a position at the moment to pay debenture interest and preference dividend due at the end of last year owing to a receiver having been appointed in the case of one of their large customers.

Elliot's Metal Company, Limited.—Interim dividend of 1s. per share, less tax, on ordinary shares. A similar dividend will be paid in respect of new shares which are to be issued in exchange for shares in Muntz's Metal Company.

Tully Gas Plants, Limited.—Capital £150,000 in £1 shares (100,000 8 per cent. cumulative participating preferred shares and 50,000 ordinary), to acquire the undertaking of Bale & Hardy, Limited, and to carry on the business of contractors, electricians, electrical and gas engineers, founders, smiths, etc. Purchase consideration, £43,650, payable in shares.

George & Ormerod, Limited.—Capital £3,000 in £1 shares, to carry on the business of mechanical engineers, iron and brass founders, etc., and to take over the business of an engineer carried on by A. C. George at Heath Street, Salford, Lancs., as George & Ormerod.

Deaths.

MR. GEORGE A. LUNDIE, C.E., who for many years was the engineer of the Rhymney Railway, has died. Deceased, who was in his 79th year, was the only surviving son of the late Mr. Cornelius Lundie, who was the general manager of the Rhymney Railway.

MR. PERCY THOMAS, a well-known civil engineer, died at sea on the 15th ult. while returning from Brazil. He was 45 years of age and a son of the late Mr. W. H. Thomas, of Manchester. He was formerly with Messrs. Wills & Son, and subsequently with Sir John Norton Griffiths on a number of Government building works.

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION.—The next meeting of the Section will be held in the rooms of the Chemical Society, Burlington House Piccadilly, W. on Monday next, February 7, at 8 p.m., when the following paper will be read:—"The Erosion of Bronze Propellers," by Dr. O. Silberrad. The members of the Section will dine together before the meeting at the Florence Restaurant, Rupert Street, W., at 6.15 p.m. (dinner 6s. 6d.). Members intending to be present at the dinner will please notify the Hon. Secretary as early as possible, so that the necessary arrangements may be made.

Personal News.

AT the annual meeting of the Society of Yorkshiremen in London Sir Hugh Bell, H.M. Lieutenant of the North Riding, was unanimously elected president for the ensuing year, in succession to Lord Stuart of Wortley.

THE late Mr. Wilson Hartnell, of Aysgrath, Roundhay, Leeds, electrical engineer, a member of the Institute of Mechanical Engineers and head of Wilson Hartnell & Company, Limited, who died on November 10 last, left estate of the gross value of £10,777 5s. 1d., with net personalty £10,692 10s. 10d.

THE appointment of Mr. F. H. Wynne to be Divisional Inspector of Mines for Yorkshire and the North Midlands in succession to Mr. T. A. Mottram is announced. Mr. Wynne has recently been assistant to the Chief Inspector at the Home Office, but for nearly four years previous to March, 1917, he served as senior inspector in the Durham and North Yorkshire (Cleveland) division.

IT is announced that Mr. H. J. Parry has resigned from his position as director and general manager for G. P. Wincott, Limited, furnace builders, Sheffield. Mr. Parry went to Sheffield in 1913, and during the war he did a great amount of valuable work in designing furnaces for re-heating, press and rolling mill re-heating, and general heat treatment of steel, which had the effect of expediting the production of munitions, and particularly of reducing fuel consumption.

Legal.

Railway Rates Disputed.

An action brought by the North-Eastern Railway Company against Messrs. Dorman, Long, & Company, Limited, for £57, was heard in the Middlesbrough County Court, by his Honour Judge McCarthy.

Mr. Mundahl appeared for the N.E.R., whilst Mr. Paley Scott was retained for Messrs. Dorman, Long & Company.

It appeared that the case arose in the following manner. In 1894 the N.E.R. Company acquired several small local railways belonging to the Middlesbrough Owners. Section 18 of the Act, under which the acquisition was made, provided that persons who had been using the railway should not be charged more in future than they had hitherto been charged, and this privilege was further confirmed by an Act dealing with railway rates in 1892.

Payments proceeded under these two acts up to 1919, when the Ministry of Transport Act was passed. This act, by Section 3, gave the Minister wide powers in regard to the increase of tolls and charges, and the alteration of agreements all over the country. The Minister of Transport ordered the N.E.R. Company to double its charges to those persons who had acquired the privilege of fixed charges over the Middlesbrough Owners' Railways. Messrs. Dorman, Long & Company resisted this charge and the present action was the outcome.

The whole question in the action was whether the powers given to the Minister of Transport by the Act of 1919 were sufficient to override and abrogate the rights and privileges secured under earlier Acts.

After hearing the arguments of counsel His Honour said he would give judgment on February 10.

Church-bells are being made in Germany from electric steel, which is said to give as good results as bronze.

The Schiess Maschinen-Fabrik of Düsseldorf has introduced an improved machine for drilling ship and boiler plates. It is operated by one man, who can shift the position of the drill or the plate at will, and can do twice or thrice the amount of work formerly done by two to three men.

Dr. Kessner, who won the Carnegie medal a year or two before the war for a drill test for determining the hardness of metals, has just patented a simplified drill which will probably displace the spiral drill, as it can be made at half the cost of the latter. He uses a bar of electric steel, a cross-section of which resembles a double T.

MR. ARTHUR HAYDAY, M.P., the Nottingham district secretary of the Union of General Workers, has been informed that many Midland blast-furnace owners are to extinguish furnaces and damp down others. Six thousand men are affected in the Midland area, many of whom are now working on day-to-day terms. A crisis is approaching, says Mr. Hayday, and the coal industry and engineering may soon be involved.

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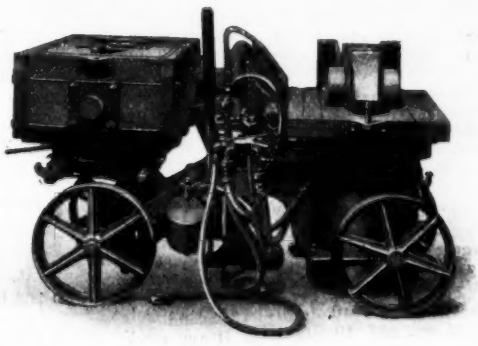

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WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	67	12	6
Three months	70	0	0
Electrolytic	76	5	0
Tough	73	10	0
Best selected	73	10	0
Sheets	124	0	0
India	124	0	0
Wire bars	75	15	0
Do. Feb.	75	15	0
Do. Mar.	75	15	0
Ingot bars	75	10	0
H.C. wire rods	85	10	0
Off. aver. cash, Jan.	71	1	4⅝
Do. 3 mths., Jan.	71	9	4⅞
Do. Settlement Jan.	71	0	2⅝
Do. Electro, Jan.	80	3	1½
Do. B.S., Jan.	77	13	9
Aver. spot, copper Jan.	70	19	9¼
Do. Electro, Jan.	81	3	8¼

Solid drawn tubes 17d.
Brazed tubes 17d.
Wire 14¼d.
Yellow metal rods 9½d.
Do. 4x4 Squares 13½d.
Do. 4x3 Sheets 13½d.

BRASS.

Solid drawn tubes 14½d.
Brazed tubes 17¾d
Rods 13¾d.
Sheets to 10 w.g. 13d.
Wire 12⅞d.
Rolled metal 12½d.

TIN.

Standard cash	168	10	0
3 Months	173	15	0
English	163	0	0
Bars	165	0	0
Chinese	162	0	0
Straits	187	0	0
Australian	178	0	0
Eastern	236	0	0
Banca	193	10	0
Off. aver., cash, Jan.	190	13	11½
Do. 3 mths., Jan.	195	18	11½
Do. Sttlment., Jan.	190	10	0
Aver. spot, Jan	190	9	6¼

SPELTER.

Ordinary	24	10	0
Remelted	18	15	0
Hard	17	10	0
Electro 99.9	34	10	0
English	26	15	0
India	21	0	0
Prime Western	26	0	0
Zinc dust	60	0	0
Zinc ashes	6	10	0
Off. aver., Jan.	25	15	7½
Aver., spot, Jan.	25	5	5¼

LEAD.

Soft foreign ppt	23	0	0
English	25	0	0
Off. average, Jan.	23	12	6½
Average, spot, Jan.	23	7	8¾

ZINC SHEETS.

Zinc sheets, spot	40	0	0
Do. V.M. ex. whf.	40	0	0
Do. ppt., f.o.b., N.Y.			—
Dutch	39	5	0
Boiler plates	37	5	0
Battery plates	37	10	0

ANTIMONY.

English regulus	40	0	0
Special brands	42	0	0
Chinese	25	0	0
Crude	23	0	0

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FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—
45/50% £19 0 0
75% £29 0 0
Ferro-vanadium—
35/40% 30/- lb. va.
Ferro-molybdenum—
70/80% 7/9 lb. mo.
Ferro-titanium—
23/25%, carbonless 1/6 lb.
Ferro-phosphorus, 20/23%, £49
Ferro-tungsten—
80/85%, carbon low 2/2 lb.
Tungsten metal powder—
98/99% 3/3 lb.
Ferro-chrome—
4/6% car. £37 10
6/8% car. £37
8/10% car. £36 10
Ferro-chrome—
Max. 2% car. £87
Max. 1% car. £104
Max. 0.75% car. £120
65/75%, carbonless 3/- lb.
Nickel—99·8% cubes or pellets £215
Cobalt metal—97% 20/- lb.
Aluminium—98/99% £165
Metallic Chromium—
98/99% 7/6 lb.
Ferro-manganese—
76/80%, loose £28
76/80%, packed £28
76/80%, export £29
Metallic manganese—
98/99%, carbonless 3/6 lb.
Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

	s.	d.
Finished bars, 14% tungsten	3	2
Finished bars, 18% tungsten	4	0

Scrap pieces 5d.
Turnings and swarf 3d.
Per lb. net, d/d buyers' works.
Extras—
Rounds and squares 3 in. to 8 in. inclusive 4d. lb.
Rounds and squares under ½ in. to ¼ in. 3d. lb.
Flats under 1 in. by ⅝ in. to ½ in. by ¼ in., and all sizes over four times in width over thickness 3d. lb.
Bevels of approved sizes and sections 6d. lb.
If in coils 3d. lb.
Packing 4s. cwt
Bars cut to length 10% extra
Scrap from high-speed tool steel—
Scrap pieces 5d.
Turnings and swarf 3d.
Per lb. net, d/d steel makers' works.

SCRAP.

	£	s.	d.	£	s.	d.
South Wales—£ s. d.						
Heavy Steel	5	10	0			
Bundled steel & shearings				5	10	0
Mixed iron & steel	2	0	0	5	0	0
Heavy cast iron				6	10	0
Good machinery for foundries				10	0	0
Cleveland—						
Heavy steel				5	10	0
Steel turnings				5	0	0
Steel borings				5	0	0
Heavy wrought iron piling				8	0	0
Bundling scrap				7	10	0
Cast-iron scrap				10	5	0
Lancashire—						
Cast iron scrap				10	0	0
Heavy wrought				8	0	0
Steel turnings				5	10	0
London—						
Copper (clean)				55	0	0
Brass (clean)				35	0	0
Lead (less usual draft)				18	10	0
Tea lead				16	10	0
Zinc				11	0	0
New aluminium cuttings				95	0	0
Braziery copper				44	0	0
Gun metal				50	0	0
Hollow pewter				120	0	0
Shaped black pewter				80	0	0

PIG-IRON.

N.-E. Coast—	
Foundry No. 1	225/-
Foundry No. 3	215/-
Forge No. 4	212/6
Mottled	212/6
Hematite No. 1	242/6
Hematite M/Nos.	240/-
Midlands—	
Staffs. common	195/-
,, part-mine forge	235/-
,, ,, foundry	240/-
,, Cold blast	360/-
,, basic	205/-
Northants forge	207/6
,, foundry No. 3	230/-
,, basic	205/-
Derbyshire forge	225/-
,, foundry No. 3	235/-
,, basic	230/-
Scotland—	
Foundry No. 1	260/-
,, No. 3	255/-
Hematite M/Nos.	230/-
Sheffield (d/d district)—	
Derby forge	220/-
,, foundry No. 3	230/-
,, basic	220/-
Lincs. forge	215/-
,, foundry No. 3	220/-
,, basic	190/-
E.C. hematite	253/-
W.C. hematite	255/-
All d/d in the district.	
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, foundry No. 3	245/-
Northants foundry No. 3	245/-
Cleveland foundry No. 3	232/6
Staffs. foundry No. 3	250/-
Lincs. forge	—
,, foundry No. 3	—
Summerlee foundry	272/6
Glengarnock foundry	272/6
Gartsherrie foundry	272/6
Monkland foundry	272/6

FINISHED IRON & STEEL.

Iron—	£	s.	£	s.	d.
Bars (cro'n)	24	0	26	10	0
Angles	24	10	27	0	0
Tees to 3 united ins.	25	0	27	10	0
Nut and bolt			26	10	0
Hoops			26	5	0
Marked bars (Staffs.)			31	10	0
Gas strip			32	10	0
Bolts and nuts, ¾ in. × 4 in.			51	0	0
Steel—					
Ship plates			22	10	0
Boiler plates			29	0	0
Chequer plates			25	10	0
Angles			21	0	0
Tees			22	0	0
Channels			21	10	0
Joists			21	0	0
Rounds, ⅜ in.–3-in.			22	0	0
Rounds, 3 in.–5¼ in.			21	0	0
Flats, 5 in.–8 in.			21	10	0
Flats over 8 in.			21	0	0
Rails, heavy			21	0	0
Fishplates			27	0	0
Hoops			23	0	0
Black sheets, 24 g.			24	10	0
Galv. cor. sheets, 24 g.			26	0	0
Galv. fencing wire, 8 g. plain			34	0	0
Rivets, ½ in. dia			36	0	0
Billets, soft			15	0	0
Billets, hard			16	0	0
Sheet and tin bars			17	10	0

PHOSPHOR BRONZE.

Rolled.	Per lb. s. d.
¼ in. to 1 in. wide	2 0½
1 in. to 1½ in. wide	1 11½
1½ in. to 2 in. wide	1 10½

Strips.	s. d.
2 in. to 6 in. to 26 S.W.G.	1 9¾
6 in. to 12 in. to 26 S.W.G.	1 9¼
Sheets.	s. d.
12 in. to 18 in. to 24 S.W.G.	1 10
18 in. to 24 in. to 24 S.W.G.	1 10¼
24 in. to 30 in. to 20 S.W.G.	1 11¼
30 in. to 36 in. to 16 S.W.G.	2 0¼
36 in. to 42 in. to 16 S.W.G.	2 1½

Extras.
For Gauge: Any width up to 36 in. wide, ¼d. per lb. per thinner gauge.

Drawn Rods.	s. d.
¼ in. to ½ in. dia. in random lengths; ⅝ in. to 1½ in. dia. in random lengths	1 10½
Over 1½ in. to 1¾ in.	1 10½
Tubes—basis price	2 0½

Delivery 2 cwt. free to any town.
10% phosphor copper, £40 above price of B.S.
15% phosphor copper, £50 above price of B.S.
Phosphor tin (5%), £30 above price of English ingots.
Charles Clifford & Son, Limited, Birmingham.

NICKEL SILVER, SHEET METAL, WIRE AND TUBES.

	Per lb.
Ingots for raising	1/3 to 1/9
Rolled—	
To 9 in. wide	1/10½ to 2/4½
To 12 in. wide	1/11 to 2/5
To 15 in. wide	2/- to 2/6
To 18 in. wide	2/1 to 2/7
To 21 in. wide	2/2 to 2/8
To 24 in. wide	2/3 to 2/9
Ingots for spoons and forks	1/3 to 1/9
Ingots rolled to spoon size	1/6 to 2/-
Wire round—	
3/0 to 10. G.	2/1 to 2/8

with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	33.25
No. 2 foundry Valley	30.00
No. 2 foundry, Birm.	27.50
Basic	31.96
Bessemer	33.96
Malleable	33.96
Grey forge	33.96
Ferro-manganese, Atl. port	100.00
Bess. rails, h'y, at mill	45.00
O.-h. rails, h'y, at mill	47.00
Bess. billets	43.50
O.-h. billets	43.50
O.-h. sheet bars	47.00
Wire rods	57.00
	Cents.
Iron bars	2.70
Steel bars	2.35
Tank plates	2.65
Beams, etc.	2.45
Skelp, grooved steel	2.45
Skelp, sheared steel	2.65
Steel hoops	3.05
Sheets, black, No. 28	4.35
Sheets, galv., No. 28	5.70
Sheets, blue an'l'd, 9&10	3.55
Wire nails	3.25
Plain wire	3.25
Barbed wire, galv.	4.10
Tinplate, 100-lb. box	$7.00

COKE.

Welsh foundry	72/6
,, furnace	57/6
Durham & North. foundry	70/-
,, furnace	59/6
Other Districts, foundry	77/9
,, furnace	55/-

SWEDISH IRON.

Bars, hammered basis sizes ..	Basis price.	
Rolled Ordinary— Assortment ..	£ s. d. 31 0 0 to 38 0 0	
Nail Rods— Square, round and flats ..		
Keg Steel / Faggot Steel	about £50	Prices nominal.
Blooms— Single welded ..	£20 to £25	
Billets— Single and double welded ..	£22 to £27	
Pig-Iron— Grey, white or mottled ..	£15 to £20	

Prices are without engagement. All quotations are f.o.b. Gothenburg, net cash against documents there.

TUBES.

	Up to and incl. 2 in.	Over 2 in.
Gas ..	net	−5%
Water ..	+10 %	+ 3⅛%
Steam ..	+21¼%	+13⅜%

REFRACTORIES.

	£ s. d.
Magnesite bricks, 2½ in., d/d	137 10 0
Do. 3 in., d/d	165 0 0
Common firebricks, 2½ in., d/d	10 0 0
Do. 3 in., d/d	12 0 0
Scotch firebricks, 2½ in., f.o.r.	12 15 0
Do. 3 in., f.o.r.	15 7 6
Sheffield quality, 2½ in., f.o.r.	11 0 0
Do. 3 in., f.o.r.	13 5 0
Silica bricks (ord.), 2½ in., f.o.r.	15 10 6
Do. 3 in., f.o.r.	18 12 6

All per 1,000 bricks.

Basic Dolomite ..	3 18 0
Dead burnt magnesite (peas and powder), d/d ..	26 0 0
Ground fireclay	1 10 0 to 2 0 0
Ganister	1 10 0 to 1 12 6

TINPLATES.

I.C. Cokes, 20×14, box	33/–
,, 28×20, ,,	66/–
,, 20×10, ,,	47/–
,, 18⅞×14, ,,	36/–
Terneplates, 28×20, ,,	70/–

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£ s. d.	
Jan. 26	68 2 6 inc.	17/6
,, 27	69 10 0 inc.	27/6
,, 28	67 15 0 dec.	35/–
,, 31	67 15 0 No change	
Feb. 1	69 12 6 inc.	37/6

Standard Tin (cash).

Jan. 26	169 10 0 inc.	100/–
,, 27	174 10 0 inc.	100/–
,, 28	167 10 0 dec.	140/–
,, 31	168 10 0 inc.	20/–
Feb. 1	168 10 0 No change	

Zinc Sheets (spot).

Jan. 26	40 0 0 No change	
,, 27	40 0 0 No change	
,, 28	40 0 0 No change	
,, 31	40 0 0 No change	
Feb. 1	40 0 0 No change	

Spelter (ordinary).

Jan. 26	24 0 0 No change	
,, 27	24 0 0 No change	
,, 28	24 0 0 No change	
,, 31	24 10 0 inc.	10/–
Feb. 1	24 10 0 No change	

Lead (English).

Jan. 26	25 10 0 inc.	10/–
,, 27	25 0 0 dec.	10/–
,, 28	25 0 0 No change	
,, 31	25 0 0 No chang	
Feb. 1	25 0 0 No change	

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5959 Central.

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CUPOLA FOREMAN.—Wanted for large Foundry, making highest class of Engine Castings, a Foreman capable of controlling the output of eight Cupolas melting highest grade of cast iron. Applicants must be first-class men on Cupola Practice, and understand what is going on inside as well as outside the Cupola. State age, experience and salary expected to Box 662, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, Strand, London, W.C.2.

FOREMAN COREMAKER required for large Foundry on the Clyde making high-class Engine Castings. Applicants must be well up in making large and small cores in sea-sand and oil, and be capable of supervising Core Shop on modern lines.—Apply, stating age, experience and salary expected, to Box 664, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, Strand, London, W.C.2.

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WELL-KNOWN Consulting Marine Engineer and Naval Architect, practising on the North-East Coast, is prepared to negotiate for the purpose of taking up Agencies.—Address Box 650, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

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TO IRONMASTERS AND MINING CORPORATIONS.—Cuban Iron Ore Deposits for disposal. (a) 100 million tons Limonite Ore, on favourable terms. (b) 400 million tons Limonite Ore, on exceptional terms. (c) 50 to 100 million tons High Grade (hard) Hematite Ore; mining rights may be arranged under royalty.—Particulars from Box 652, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2

WANTED all users of METALLIC CEMENT to buy our PEERLESS brand, which produces "Artificial Iron" 10 lb. tin 10s., free delivered.—WILLIAM OLSEN, LTD., Cogan Street, Hull.

ADVICE and Handbook Free.—KING'S PATENT AGENCY, LIMITED, Director, B. T. King, Reg. Patent Agent, 165, Queen Victoria Street, E.C.4.

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PATTERNS SUPPLIED WHICH GIVE SATISFACTION. Inquiries solicited. Quotations by return of post or telephone. You can secure good-class work, reasonable prices, and promptitude in delivery by placing your orders with VIDEX ENGINEERS' PATTERN WORKS, 22, Huntsworth Mews, Upper Baker Street, London, N.W.1 (Telephone, Paddington 364).

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MACHINERY.

TURN TO THE B.W.S. ANNOUNCEMENT, PAGE 11.

WANTED, good second-hand Pig-iron Breaker, preferably belt drive; must be in good order and cheap for cash.—Box 668, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

TILTING FURNACE (M.R.V. or Morgan) Wanted, about 400-lb. capacity; must be in good working condition.—Send full particulars to Box 658, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, Strand, London, W.C.2.

FOR SALE.—1 new No. 6 Ajax Jarring Turnover and Pattern Drawing Moulding Machine; maximum size of box 25 in x 25 in. x 18 in., pattern lift 14 in. 1 Ingersoll Rand Air Compressor, 7 in. x 6 in., class E.R.1, for 80/100 lbs. pressure.—H. L. RAPHAELS'S REFINERY, Thomas Street, E.14.

FOR SALE, Cornish Boiler, 15 ft. × 5 ft., with fittings for 90 lbs., by Tangye. Also Cornish Boiler, 12 ft. × 4 ft. 6 in., with fittings for 70 lbs.; and Vertical Boiler, 6 ft. × 3 ft., with fittings for 50 lbs. Foundry Overhead Crane, 16-ft. span, to lift up to 4 tons, complete with worm-geared blocks and travelling cradle. Four-wheel Boiler Wagon, to carry up to 5 tons, suitable for heavy castings.—GEO. DEAN, Engineer, Stockton Brook, Stoke-on-Trent.

MACHINERY—*Cont.*

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One LANCASHIRE BOILER, 30 ft. by 8 ft. diameter, reinsure 120 lbs. pressure.
One ditto, 30 ft. by 7 ft. 6 in. diameter, reinsure 140 lbs. pressure.
One ditto, 24 ft. by 7 ft. 9 in. diameter, reinsure 100 lbs. pressure.
Two CORNISH BOILERS, 28 ft. by 6 ft. diameter, reinsure 90 lbs. pressure.
One ditto, 19 ft. by 5 ft. 6 in. diameter, reinsure 80 lbs. pressure.
One GALLOWAY BOILER, 17 ft. by 5 ft. 6 in. diameter, reinsure 80 lbs. pressure.
Three MARINE WATER-TUBE BOILERS, by Yarrow, each 4,000 sq. ft. htg. surface, reinsure 200 lbs. pressure.
Two MARINE BOILERS, 10 ft. 4 in. long by 12 ft. 2 in. diameter, reinsure 150 lbs. pressure.
One Spencer-Hopwood VERTICAL BOILER, 10 ft. 8 in. by 4 ft. 9 in. diameter, reinsure 100 lbs. pressure.
One ditto, ditto, 9 ft. 9 in. by 4 ft. 3 in. diameter, reinsure 100 lbs. pressure.
One LOCO-TYPE BOILER, barrel 12 ft. long by 4 ft. 8 in. diameter, reinsure 150 lbs. pressure.
One ditto, barrel, 8 ft. long by 4 ft. 3 in. diameter, reinsure 100 lbs. pressure.
One ditto, barrel, 7 ft. 6 in. long by 3 ft. diameter, reinsure 80 lbs. pressure.
One ditto, barrel, 4 ft. 7 in. long by 3 ft. diameter, reinsure 80 lbs. pressure.
Several UNUSED SECTIONAL STEEL CISTERNS, 8 ft. by 8 ft. by 4 ft. deep, capacity about 1,600 gallons each.
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